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Teaching with *Style*

Computer aided instruction, personality and design education

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Thesis submitted in partial fulfilment of the requirements of the degree of Doctor of Philosophy

April 1996

Author number : A17066154
Date of submission : 2 April 1996
Date of award : 12 June 1996

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Abstract

The investigation reported in this thesis concerns the possibility of automatically matching the learning styles of design students with appropriate styles of computer aided instruction (CAI).

Individual adult learners exhibit preferences for the way information is presented and for the ways in which they are taught. These preferences arise from characteristics known as cognitive styles which are associated with personality. Cognitive dissonance occurs when there is a mismatch between styles of teaching and styles of learning. Under these conditions some students will be discouraged. A survey of students on typical design courses showed them to have particular learning preferences. In this respect they are differentiated from tutors who may prefer to teach in a different style.

CAI systems also exhibit styles. These are manifest in features such as the computer's control of learning interactions and the form of information which the system delivers. Computer-based training has often been of a sequential, drill-and-practice kind which encourages rote learning. This style has met with limited success, and it is shown to be unsuitable for most design students.

The Myers-Briggs Type Indicator (MBTI) is used to classify the psychological types of design students. Evidence of learning preferences from the MBTI and from related sources is given. From a theoretical description of learning episodes, a computer-based model is developed that provides CAI treatments matched to sixteen learning styles.

It is concluded that CAI-based teaching of technological information to design students can be more optimally matched. The principles established have wider implications for communications between designers and others.

Preface

I turned to the Open University for doctoral study because I felt that it would be experienced in looking after a part-time, distance student of mature years. This has turned out to be so.

I firstly want to thank my supervisors, Nigel Cross and Jeffrey Johnson, for their courteous and consistent help over these six years. It been a pleasure working with them. They have set demanding standards and, in the process, they have also changed fundamentally my perception of the nature of design research. Additionally, other OU staff have given advice, for which I thank them too.

Also, I must mention the various internet specialist discussion groups, individuals of which have provided emailed advice and occasional practical help in sending research papers. I thank them all for their time and their interest. This opportunity is also taken to thank staff and students of the academic institutions which participated in the survey of design students — for their organisational assistance, and for informal discussions.

And lastly, thanks to my family for being so tolerant — to my young son for not complaining (too often) when I was unable to join in his play, and to my wife who encouraged me not to give up on those numerous occasions when Hofstadter's Law[1] intervened.

1 Hofstadter's Law states: "It always takes longer than you expect, even when you take into account Hofstadter's Law" (Hofstadter, 1980, p.52)

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Chapter 1

Beginning

1 Beginning

1.1 Nomenclature

In a relatively new and expanding field such as computer aided instruction, the terms used are in a constant state of flux and precise meanings may be ambiguous or misunderstood. For the avoidance of doubt, the major terms used throughout this thesis are defined at the outset. As further terms with special meanings are introduced in the text, they are explained in footnotes.

The term *designer* means design students (and to a lesser extent qualified designers) with an *art-based* design background. Typically, this background comprises graduate and postgraduate design education which has developed through the traditions of the British Art Schools.

There are many terms in common usage which describe some form of teaching through computers. Some terms carry with them historical baggage which obscures their meaning. Other terms convey distinctions too subtle for clarity. The term *computer aided instruction* (CAI) will refer to all forms of teaching through computers. This term therefore subsumes other commonly used expressions including *computer assisted learning* (CAL); *computer based learning* (CBL); *computer based training* (CBT); *programmed learning*; and many others. In this context the term CAI denotes an intention to *teach* something through the medium of a computer, rather than the more passive methods of information retrieval from databases where learning, if any, is incidental.

CAI also denotes studying alone with a computer: it is taken to mean a standalone, self contained computer-based teaching application which does not necessarily form part of a wider learning project or programme, nor rely on other external materials.

The term *multimedia* is often used to describe the intersection of text, images and sounds under the control of a computer. However, the term *hypermedia* is used here (as a singular noun) to denote a superset of multimedia which includes techniques for the associative linking of texts and images. Hypermedia includes *hypertext*, the associative linking of documents spread across several electronic media

> "in which the elements are networked together [and] can be text, graphics, digitized speech, audio recordings, pictures, animation, film clips, and presumably tastes, odors, and tactile sensations" (Conklin, 1987)

Finally, the term *author* is used to denote those persons engaged in the design of hypermedia, especially in an educational context.

1.2 Genesis

This study began from a proposition that, under the influence of efficiencies being sought in university teaching together with the decreasing cost of computers with hypermedia capabilities, CAI is an increasingly important means of providing taught knowledge to design students. Linked to this was my wholly subjective observation that design students seem to have more difficulty in assimilating science or technology based teaching than they have with their core design studies. Therefore the main thrust of the study was to investigate possible reasons for this apparent disjunction, and to suggest ways in which CAI might help alleviate it. This investigation has therefore focused on the identification of design students' preferences for learning, and the satisfaction of those preferences through forms of computer aided instruction.

This led to a consideration of potential differences between individuals in terms of their worldviews; their attitudes towards a learning task; their preferences for learning; and their choices of media and for the presentation of materials. This in turn led to a wide ranging literature search across adult learning; human-computer interaction; history of CAI and current developments; aspects of cognitive psychology; and designers' thinking. The study finally focused on basic differences between individuals in the ways that they perceive their world,

sometimes termed *cognitive styles*. It was also felt that concentrating on a typical science or technology subject taught to designers would help focus the investigation. The field of ergonomy was chosen as being common to many design disciplines.

A central hypothesis was that

- by the specification of appropriately configured hypermedia the structure and delivery of ergonomics knowledge can accommodate the cognitive styles of design students

1.3 Research questions

Several main research questions quickly arose. Among these were

- **Are there styles of teaching and learning?**

  It would need to be shown clearly that there are important differences in preferences between individuals or between groups of individuals

- **Do designers have particular styles of learning?**

  If designers and cognate professionals have particular preferences, what are these, and can they be identified and classified?

- **Is there a mismatch between designers and some tutors?**

  If there are differences between people, what differences are discernible between teachers and learners, particularly between design students and teachers from science and technology?

- **Does CAI exhibit particular styles?**

  Is it possible to identify particular styles of presentation or delivery by CAI, and if so, are these styles intrinsic to computers?

- **Is there a mismatch between CAI and designers?**
  If there is an identifiable mismatch between CAI and the preferences of design students, can it be minimised by the authoring of more appropriate materials?

- **Can styles suitable for designers be implemented on a computer?**
  Can personal preferences be classified in such a way that they can be supported by a computer system?

1.4 Influences

Particularly with a study such as this, which ranges across disciplines, it is to be expected that many other researchers have influenced the work reported here. These influences are drawn mainly from studies of design and designing; cognitive psychology; computer science; ergonomics (in respect of human-computer interaction); and educational technology. The more important research papers and books are listed in the references section and marked in the body of the text. But there are two further significant influences which deserve a mention here. Firstly, the many researchers, teachers, and trainers with whom I have discussed these issues through the facility of several discussion lists on the Internet. The ability to converse (and at times argue) with others struggling with mutual problems and possibilities, and often from different cultures, has been of inestimable help. Secondly, in coming to the *Myers-Briggs Type Indicator* for the first time, I have been struck by the far sighted and dedicated work of Isabel Myers and her mother. Not only has their clear writing on psychological types been of considerable practical help in this study (and in understanding my own personality), but the family story is also fascinating, bound up as it is with the development of one of the most widely used psychometric instruments.

1.5 Main themes

From these diverse influences, some main themes will now be discussed as a background and introduction to the more detailed commentary in following chapters.

In a comprehensive analysis of university teaching and the potential role to be played by technological media, Laurillard (1993) has highlighted that, in over twenty years of prodigious use of information technology (IT) in education, the emphasis has been predominantly on development and use rather than research. Because new media capabilities have become available, too often these have driven the educational uses even though our understanding of these new media is poor in pedagogic terms. She suggests that two basic criteria must be addressed before embarking on a multimedia development

- set out the learning objectives
- address the learning needs of students

Broadly, it is the second of these propositions to which this thesis aims to make a contribution.

There are those visionaries who have predicted that, in the latter half of this century, we have started to experience the world's third revolution (eg. Toffler, 1980; Gassée, 1987). A significant part of the forces driving these changes is the digitalisation and global networking of information. The coming of the microcomputer has opened up enormous opportunities for easier access to information and has brought the power of computing into the home. Following in the wake of these trends, there are those such as Perelman (1992) who foretell a diminution of the formal educational system as we presently know it, and its replacement by wide scale access to knowledge through a computer screen. But, exciting though these ideas may be, caution is required. Earlier forms of CAI have had a mixed reception, and there are many arguments both for and against the use

of computer tutoring: this is leading some hypermedia authors to focus more on the needs of learners, and to begin to consider ways in which machine tutoring can adapt to individuals' learning preferences (summarised by Conner et al., 1995).

1.5.1 Design teaching

In studying several course documents from typical industrial design courses I often found a phrase such as "inculcate designerly ways of thinking" or "foster creative attitudes". There was never an exact explanation of what might be meant by these terms. Yet we do know that in certain respects designers differ from other professionals. For instance, Cross (1982; 1990) has highlighted that various studies support the view of a "designerly" activity quite separate from typical scientific and scholarly activities, and that designers are relatively happy working in areas of uncertainty or with incomplete information. These distinct differences may be observed particularly in problem solving behaviours.

Lawson (1990) showed that science students adopted a problem solving strategy which sought underlying rules and principles before proposing a solution, whereas architecture students were happier to propose solutions which they subsequently analysed. This accords with Davies' and Talbot's (1987) interviews with leading UK designers, which showed them to have a strong bias towards intuition. These interviews also showed that what designers know about their creative abilities remains largely tacit knowledge which is difficult to externalise and to express in language. It is perhaps incumbent upon design tutors to be articulate in what they are trying to teach because otherwise they will have no rational basis for choosing either content or methods of teaching. In order to provide design knowledge which is *teachable* through the medium of computers it will be necessary to make such knowledge explicit. Without clearly articulated and well understood principles of design education this may prove difficult. Although certain cognitive strategies may be particular to designers they are rarely explicitly acknowledged in design education.

It has been suggested by Cross (1985) that designers' cognitive preferences (or *styles* of thinking and of learning) should be matched to styles of teaching. He further proposed that computers may have intrinsic styles arising from their modes of working and that there is potential for mismatch between designers and computers, although little evidence is offered in confirmation. This is an important point for investigation: *if* there are designerly styles and these are consonant with learning preferences, it follows that CAI will also require a capability in delivering tuition in styles which are matched to its users. But it is by no means clear what strategies and practices might be adopted to satisfy this criterion.

1.5.2 CAI guidelines

From the many guidelines available to assist in authoring CAI according to good principles, a high proportion deal predominantly with the graphic design of screen displays (eg. Rivlin, Lewis & Cooper, 1990). This is a well researched area, but while topics such as legibility of typefaces are well covered, much advice centres on prescriptions for frames, position of buttons etc. Another kind of guidance manual concerns itself more with project planning; the identification of learning objectives; the marshalling of teaching materials; and the assembly of such materials into a computer system. One comprehensive example of this genre is Schwier & Misanchuk (1993). Sometimes highly prescriptive guidelines centre around a particular authoring template (eg. Huckbody, 1990). Often, the reported work consists of case studies of experimental computer implementations, with interim conclusions: this has been particularly true of TLTP[1] related literature, for example Donnelly (1994). In initially reviewing this literature I was left hungry for a clearer understanding of the learner's perspective on computer tutoring. In respect of CAI, what *are* learners' needs?

1 The Teaching and Learning Technology Programme (TLTP) is a UK-wide research programme which aims to bring subject specific teaching software into higher education.

Jonassen (1985) emerges as one of the strongest advocates of hypermedia promulgating new forms of learning. He states that we can conclude

> "that an individual's ability to perform certain skills or acquire certain information may be mediated by the nature of the instructional intervention or treatment. The logical implication is that we can accommodate individual differences in processing ability by altering the nature of the learner interaction in order to enable individuals with different processing capabilities to learn".

He states that the nature of the instructional treatment warrants further investigation, as

> "we might reorganize, resequence, or redesign the way information is presented".

Additionally Jonassen's (1989) viewpoint, with its antecedents in Bush's (1945) seminal article *As we may think*, is that the powerful associative qualities of hypertext will necessarily allow learners to search, compare and reformulate knowledge with an ease not previously possible with, for example, books. However, Laurillard (1993) has cast doubt on this viewpoint, believing that hypermedia will not replace textbooks though it may prove a powerful tool for reconstructing (or repurposing) knowledge.

Aside from computer games, a majority of current hypermedia output seems to be in the form of large scale databases, for example Microsoft's *Encarta*, an encyclopaedia based on compact-disk read-only memory (CD-ROM). While these databases have powerful freeform retrieval techniques, and have the advantage over books of video and sound clips, there is no structure to actively *teach* anything. Any learning is therefore uncontrolled and incidental (Lovell, 1989). A major obstacle to the use of large hypertext databases (ie. non-hierarchically structured) is that of becoming disorientated in informational space, or simply getting lost (Conklin, 1987). Various techniques have been tried, often based on metaphor, ranging across topographical devices (ie. map-like structures) to representations of books (Barker, 1991; Benest, 1990). As information bases grow ever larger the problem is likely to worsen.

1.5.3 Learning styles

Evidence for the existence of styles of learning (eg. preferences for the type and delivery of teaching materials) seems to be firmly established, and this theme will be expanded below. However, many studies are one dimensional and though they have produced acceptable theories, they have offered little in the way of firm guidance for authors. For example Witkin's (1969) observation of field-dependency and field-independency, while interesting in itself, does not produce *practical* data useful to a hypermedia author. Additionally, some researchers such as Ramsden (1992) have found that students change their learning strategy depending upon the task in hand, although there is an acceptance that a learner may have a *naturally* preferred strategy towards a learning task which s/he might change should the situation so demand: the two modes can coexist and each may be useful on various occasions.

1.5.4 Instruments

If one is interested in determining the learning styles of design students, it is necessary to find a suitable psychometric instrument which will indicate such styles. However, there are some problems inherent in the selection of instruments. There is a plethora of instruments that purport to classify learning styles and to offer advice on ways to match learning preferences to teaching methods (Gorham, 1986; De Bello, 1990). These are often self assessment questionnaires which test for learning style and categorise people into one of several styles. The robustness of many of these instruments is questionable. As an example of this, early on in the investigation I had come across several references to Gregorc's (1982) *Style Delineator.* Indeed, this had been used as a primary generator of data for a doctoral dissertation on the efficacy of matching/mismatching various kinds of presentational treatments in CAI (Hueser, 1991). But no evidence was found which would give confidence about the validity of the instrument. Several other instruments were similar: widely used, but lacking in a sufficiency of empirical validation.

Among the few instruments for which there is a sound underpinning theory the Learning Style Inventory (LSI) stands out (Kolb, 1978, 1984). It has correlations with several other scales, although in common with other learning style instruments it has limitations, some of which will be dealt with in Chapter 3. The Kolb LSI was used as one basis for the work of Powell and Newland (1994) in their work on determining architects' preferences for information retrieval, and in the design of a hypermedia system for delivering fire safety information to building design professionals. Their work was an early point of departure for me in the consideration of learning preferences by occupational groups similar to designers, and has proved to be a significant influence on the development of my thinking on the subject. Briefly, they contend that architects exhibit resistance to certain styles of information, and this is bound up with their individual worldviews which can impede information transfer. An important finding of Powell & Newland's work is that the *tone* of information must be carefully considered as this ensures that the information is perceived as having credibility by users. They have proposed an interface, based on the Kolb LSI, which has been enriched by the overlaying of additional data arising from other scales and theories. The result is a computer based system which presents information in 4 distinctly different styles which are thought to be suitable for the target audience of building design professionals[2]. Descriptions of the 4 styles provide broadly based advice to authors such as

"Make topic tangible, an experiential embrace"

"Provide practical knowledge at a general and specific level"

"Broad spectrum of information/comprehensive montage"

"Reinforce rules to guide action"

It is my understanding that the aim was to demonstrate the existence of a diversity of approaches to learning. The authors make no claim for their system generalising beyond the context of building design professionals. Their model seems adequate in this respect, and hypermedia systems which utilise this fourfold model have

2 eg. see Powell and Newland (1994) pp. 292-297, 305. The four styles of user are: Dynamic (controlling action and sensing needs); Rigorous (abstracting patterns and controlling action); Contemplative (abstracting patterns and being patient); and Focussed (being patient and having sensing needs).

been successfully developed and marketed. However, it is difficult to see how this kind of approach can form the basis of a generalisable model that might be systematically implemented on a computer, without the employment of a considerable amount of creative interpretation on the part of a hypermedia author.

1.5.5 Questions of style

In considering the extent of correspondence between style of delivery of information by a computer system and style of reception of such information by a learner, several further research questions arise

- how many styles of delivery are necessary or indeed possible? (for it seems unlikely that all human preferences boil down to a handful of styles)

- how can *credible* information be defined, and be appropriate for an individual?

- how can styles of information delivery be *systematically* implemented on a computer without considerable interpretation by a hypermedia author?

- how can a close correspondence be made between the learning style of an individual, and knowledge of the treatments required to satisfy those individual needs? It should be possible to demonstrate that the mapping of empirically based instructional treatments to individuals' styles is close and rigorous.

1.5.6 Number of styles

How many styles are reasonable to meet learners' needs? On differences centred around, broadly speaking, cognitive/learning styles and related personality characteristics, the literature shows researchers conjecturing:

- **two styles**: Witkin (field-dependent/ field-independent); Kirton (adaptors/ innovators); Hudson (syllabus-free/ syllabus-bound); Hudson (converger/ diverger); Kirby (splitters/ lumpers); Clarke, Ford (serialist/holist); and many, many more scales...
- **three styles**: Vernon (combinations of perception and judgment); Pask (serialist/ holist/ versatile)
- **four styles**: Hippocrates (sanguine/ choleric/ phlegmatic/ melancholic); Thurstone (business/ people/ language/ science); Kolb (accommodators/ divergers/ assimilators/ convergers); Powell & Newland (dynamic/ focused/ contemplative/ rigorous); Gregorc (concrete/ sequential/ abstract/ random); Keirsey (Dionysian/ Epimethean/ Promethean/ Apollonian); and many more scales...
- **five styles**: Gundlach & Gerum (technical/ social/ creative/ intellectual/ physical); Lanier (magicians/ mechanics/ merchants/ muckrakers/ mosaicists); McCrae (extraversion/ agreeableness/ conscientiousness/ neuroticism/ openness); Dunn & Dunn (environmental/ emotional/ sociological/ physical/ psychological)
- **six styles**: Spranger (economic/ social/ religious/ theoretical/ aesthetic/ political)
- **eight styles**: Jung (sensing or intuition, thinking or feeling - extraverted and introverted)
- **nine styles**: Mitchell (nine American lifestyles)
- **sixteen styles**: Myers-Briggs (ISTJ/ ISFJ/ ESTP/ ESFP/ INFJ/ INTJ/ ENFP/ ENTP/ ISTP/ INTP/ ESTJ/ ENTJ/ ISFP/ INFP/ ESFJ/ ENFJ); Cattell (16 personality factors)

There is certainly no shortage of categories. An additional and interesting problem which arises from these is the practicality of authoring in more than a small number of styles.

1.6 Structure of thesis

The approach taken in this investigation has been to apply rigorous analysis to a sometimes contradictory and confusing pattern of data. This has involved both qualitative and quantitative analyses as required, coupled with some empirical

fieldwork. During the course of the investigation several unpublished reports have been written which cover key areas of the study, and where appropriate parts of these reports have been incorporated within this thesis[3]. Due mainly to the multidisciplinary nature of this investigation together with the need to continue the argument of Chapter 2 into the following chapters, findings arising from the main literature survey are contained in Chapters 2 & 4 and, to some extent, Chapter 5.

The thesis is argued:

firstly, by comparing

- styles of people (cognitive styles; learning preferences; personality)

  with

- specific preferences exhibited by designers

Secondly, by examining

- styles of computing (history of CAI; instructional treatments; control of learning)

Thirdly, by synthesising these ideas into

- a computer-based model for authoring and delivering educational materials in styles suitable for designers

Fourthly, by discussing

- the issues which have arisen, in the context of possibilities for future research

3 Reports have included: *Hypermedia for Learning: a review* (1992); *Adult Learning and Cognitive Styles* (1993); *Designer Styles: thinking, creativity & personality* (1994); *Human-computer interaction: a position paper* (1994); *Feeling, Jung in art: a discussion document on personality traits and learning preferences in design education* (1994); *True to Type: designers, personality, and computer assisted instruction* (1995).

Chapter 2

Styles of people

2 Styles of people

2.1 Introduction

It may be conjectured that design students have particular ways in which they prefer to learn, and that teachers have individual ways in which they like to teach. These ways of teaching and learning seem bound up with aspects of cognition and with personality. There have been many enquiries into the nature of cognition, but there are obstacles to obtaining relevant data. Firstly, comparison between studies is sometimes difficult due to dissimilarities between the psychological instruments used. Secondly, there are few data for designers *per se* though there have been some larger studies of related professions such as architecture and art.

2.1.1 Aims

This chapter outlines the results of an extensive search of the psychology literature[1] and other sources aimed at finding evidence of cognitive differences between individuals or groups of professionals that will throw light on how designers learn, and which are of relevance in understanding the authoring of CAI in relation to design education. Some common characteristics of personality are compared with designers' specific characteristics which provide some background as to how designers view their world. In addition, the search has revealed aspects of personality which are of particular importance in understanding the nature of designers' creativity and its potential links with learning. The aims of this chapter are therefore to provide some background to discussing designers' specific styles of learning by outlining

- individual and group differences in psychological characteristics
- designers' thinking
- teaching and learning design

1 There is a large number of studies of learning related to children. Where possible, this search has concentrated on *adult* learning.

2.2 Intelligence

The considerable differences that exist in human intellectual abilities can be expressed as a single quantified factor termed an *intelligence quotient* (IQ). Such tests might provide pointers to associated teaching and learning preferences. However, Shouksmith (1970) among many others has cast considerable doubt on what constitutes intelligence, and Torrance (1962) showed that no correlation exists with creative potential. Additionally, Witkin (1969) demonstrated that intelligence tests do not correlate well with results of cognitive experiments.

There is much evidence that IQ tests are culturally situated, usually in western cultures. Evidence of abilities not detectable by IQ tests comes particularly from studies of non-western peoples. These studies include exceptional spatial performance among Australian aboriginals (Knapp & Seagrim, 1981) and among Inuit children (Gardner, 1993). Similarly, a study of general intelligence and spatial abilities in industrial design students showed that, as a predictor of success in industrial design studies, spatial ability tests are more effective than general intelligence tests (Yeomans, 1984). In reviewing the evidence against IQ tests, Flynn (1987) argued, with some degree of certainty, that IQ is not a good predictor of general cognitive abilities or preferences.

2.2.1 Multiple intelligences

One theory gaining acceptance is that of *multiple intelligences* (Gardner, 1993, 1995), where abilities are seen as arising from several discrete intelligences. Thus a person may have preference for one kind of intelligence and develop it to a higher degree than an intelligence not so favoured. Gardner has identified seven proposed, but tentative, intelligences: these are linguistic; logical-mathematical; musical; spatial; bodily-kinesthetic; and personal intelligences — directed towards oneself, and directed towards others.

2.2.2 Brain lateralisation

Much excitement was generated by the *neocortical commisures* performed in the early 1960s on patients suffering from severe epilepsy (Sperry, Gazzaniga, &

Bogen, 1969). The operations involved isolating the frontal lobes by severing the *corpus callosum* which connects the two brain hemispheres. It was known that the left brain hemisphere is responsible for right-side body control and sensation, while the right hemisphere is responsible for left-side control and sensation. However, the so called *split brain* patients appeared to show that the processing required for certain cognitive functions was handled predominantly in one brain hemisphere or the other. There is a wealth of reported findings and theories on thinking and learning modes arising from considerations of hemisphericity (Bogen, 1977; Wittrock, 1977; Dunn & Cavanaugh, 1982). It was at first thought that each hemisphere was solely responsible for certain kinds of processing, but later studies have shown processing to be more of a whole brain activity, though each hemisphere demonstrates certain lead characteristics in processing. Bogen (1969) conjectured an analytical and rational way of thinking for the left brain which he termed *propositional* thinking. Conversely, he coined the term *appositional* to indicate typical right-brain characteristics: this implied a capacity for apposing or comparing perceptions, and was seen as a freer mode of thinking. In reviewing the subject more recently, Zenhausern (1990) found

> "there is clear evidence that the left hemisphere has unique control of expressive speech and operates using a sequentially organized system. The right hemisphere, on the other hand, has systems that are more capable of spatially and pictorially oriented processing".

In the wake of conflicting evidence, researchers such as Gardner (1982) have cautioned against too literal a view of results, but broad conclusions may be summarised as follows.

Left brain	Right brain
abilities in language and number	visuo-spatial abilities
serial and analytical modes	holistic and synthetical modes
discrimination of detail	discrimination of wholes

Figure 2.1: Hemispheric abilities

2.2.3 Left-handedness

As motor coordination of the left hand is under right brain control, it has been thought that left-handed individuals will show more ability in right brain activities such as visuo-spatial processing. Peterson & Lansky (1974) studied 484 students

and 17 full time architect tutors in one department of architecture and found both groups to be more left-handed than would be expected. The norm for left-handedness in the population was defined as 8-10%. Of the staff, 29% were left-handed. Of the students, left-handers represented 23.9% in one year group and averaged 16.3% across all student groups. In a related spatial awareness task, left-handers exhibited 100% accuracy, whilst on the other hand (so to speak) right-handers achieved accuracy of less than 50%. Peterson & Lansky concluded that although

> "the matter is not simple, it appears safe to say that the left hemisphere goes more with right-handedness and verbal abilities, the right hemisphere more with left-handedness and greater spatial competence".

2.3 Worldviews

There is an extraordinary complexity to the range of interactions between an individual's cognitive strategies, personal tastes, and other mental preferences. These shape individuals' views of their world and, among other things, provide a framework for the particular ways in which people think and act.

2.3.1 Personality

Broadly, we often refer to the outward manifestation of these relatively stable and enduring behaviours as a person's character or *personality*. Personality may be thought of as a unique pattern of *traits*, where a trait is defined as

> "any enduring way in which persons differ from one another" (Guilford, 1950).

These traits can be categorised broadly as aptitudes, interests, attitudes, and temperamental qualities. Although there is clearly overlap with cognitive performance and preferences, personality deals more with *attitude* (a tendency to favour, or not to favour, some types of object or situation) and *temperament* (general emotional disposition eg. optimism, moodiness, self-confidence, nervousness etc.), or what we would readily observe as an individual's character.

2.3.2 Cognitive styles

Another aspect of human mentation concerns cognition and *cognitive styles.* Cognition[2] is

> "a general term covering all the various modes of knowing - perceiving, remembering, imagining, conceiving, judging, reasoning"

Cognitive styles are self-consistent ways of functioning which an individual exhibits in perceptual and intellectual activities, and they have been defined as characteristic ways in which an individual goes about *taking in* information from the world (Cropley, 1967), and as preferred ways of *organising* that information (Messick, 1976). Cognitive styles are stable over time and context, and are independent of levels in abilities, skills or intelligence (Messick, 1976); this stability suggests a relationship to individual personality characteristics (Goldsmith and Blackman, 1978).

2.3.3 Dissonance

Festinger's (1957) *Theory of Cognitive Dissonance* proposes that individuals strive towards consistency, that opinions and attitudes tend to occur in clusters which are internally self consistent, and that people believe in what they do. Congruence of attitudes is termed *consonance* where there is close matching, and *dissonance* where there is mismatch. Where there is dissonance the individual strives to modify beliefs or behaviour to arrive at a less dissonant state. If individuals are unable to rationalise inconsistencies for themselves and non-fitting relations among cognitions continue, psychological discomfort is experienced. This is important for learning, for Festinger argues that

> "Forced or accidental exposure to new information which tends to increase dissonance will frequently result in misinterpretation and misperception of the new information by the person thus exposed in an effort to avoid a dissonance increase."

Similarly, where dissonance in communications exists between persons, this

> "...will lead to seeking out others who already agree with [knowledge] that one wants to establish or maintain..."

Influence exerted on a person which produces an opinion change (such as in teaching) will be more effective where that opinion change reduces dissonance.

2 As defined by Drever's Dictionary of Psychology

Rokeach (1960) has similarly shown that individuals organise their world of ideas, people and authority along lines of belief congruence. Beliefs may be deeply held. What is not congruent is further organised in terms of similarity to what is congruent, thus incoming data are adjusted to fit the individual's underpinning beliefs. Laurel (1991) has postulated that human tutors have individual teaching styles, a significant consequence of which is that information is shaped and delivered consonant with the tutor's personal viewpoint. It therefore follows that a tutor's particular teaching style may not suit all learners. Under these circumstances cognitive dissonance can occur, and there may be poor understanding between tutor and learner.

2.4 Creativity

Designers may be said to be *creative.* Creative ability might therefore be an influence upon design students' attitudes toward learning. But what *is* creativity? For Taylor & Barron (1963) creativity was seen as thinking which results in the production of ideas that are both *novel* and worthwhile. Hudson (1966) thought it may be expressed in the production of artifacts of a notable degree of *originality* . Bruner (1962) defined creative enterprise as simply an act that produces effective *surprise*. Guilford (1950) pointed to an important and persistent feature of creativity — the ability to set aside established conventions and procedures. Fryer (1989) showed that lecturers' own views of creativity are that most perceive it to be mainly imagination, originality, and self-expression, and that it is quite distinct from intelligence.

Separating originality from the merely eccentric can prove difficult. For example, a research subject tested with cards of the Rorschach psychodiagnostic[3] was asked to tell what he saw in each blot. Instead of looking directly at the test cards, he inspected them edgewise and even bent cards in the middle to produce variations in the area he could see. He gave responses unique to the examining psychologist. The examiner — a veteran of several thousand such tests — was certain that the subject's responses were original because the test manual defines an original

3 A set of ink blots of ambiguous form, from which patterns may be perceived.

response as one that occurs no more often than once in 100 examinations (Barron, 1965). But is this creative or merely *eccentric* behaviour? The eccentric may not be creative even though it is, in a strictly statistical sense, uncommon. A practical criterion of creativity is therefore difficult to establish because creative acts of an unquestioned excellence are rare.

2.4.1 Creative personality

Rogers (1954) showed creative personality as a pattern of cognitive traits which are characteristic of creative persons. This pattern is manifest in creative behaviour, including inventing, designing, planning etc., and people who exhibit these traits are said to be creative. However, the impulse to create in the arts seems to arise in different sorts of persons than does the impulse to create in scientific circles (summarised by Terman, 1947). In a review Barron (1965) found that compared with those of high IQ, creative types often exhibit more openness to experience, more flexibility, unconventionality, playfulness, and independence. Rogers (1954) summed up this flexible thinking as follows

> "Associated with openness and lack of rigidity is the ability to play spontaneously with ideas, colours, shapes, relationships, to juggle elements into impossible juxtapositions, to shape wild hypotheses, to make the given problematic, to express the ridiculous, to translate from one form to another, to transform into improbable equivalents. It is from this spontaneous toying and exploration that there arises the hunch, the creative seeing of life in a new and significant way"

In various psychological assessments of highly creative persons distinguished by contributions to their field, there is a high degree of *similarity* across disciplines. In this respect Cattell & Butcher (1968) observed that

> "it would almost seem as if the differences between science, art and literature are differences of particular skills and interests only, and that the fundamental characteristic of the creative, original person is a type of personality".

2.4.2 Convergers and divergers

One important distinction, made by Hudson (1966), is between abilities for *convergent* thinking and for *divergent* thinking. In problem solving, convergent thinking aims toward producing a single correct answer to a problem. Divergent thinking aims to produce many ideas any of which might be suitable.

Convergent thinking involves moving progressively toward a single right answer, or thinking towards an answer that is relatively unique. This may be seen as logical reasoning with one single answer as its goal. Convergent thinking moves towards responses that fit the known and the specified. Conventional IQ tests have emphasised convergent thinking. Kolb & Goldman (1973) described the converger's greatest strength being in the practical application of ideas. The converger's practical knowledge is organised in such a way that, through hypothetico-deductive reasoning, they can focus it on specific problems. The converger style is, for instance, characteristic of many engineers (McCaulley, 1990).

Divergent thinking, on the other hand, is used in situations which call for the generation of ideas. It is synonymous with ideation and a fluency of unusually associated ideas. It is a type of thinking in which there may be considerable searching. A number of answers will be acceptable, and there is not necessarily a unique correct answer. Divergent thinking moves away from responses already known and expected. The diverger is shown by Kolb (1984) to have greatest strength in imagination, and excels in the ability to view concrete situations from many perspectives and to organise many relationships in meaningful ways. Lawson (1990) has characterised designing as a divergent activity: however, both divergent and convergent thinking must be employed from time to time in the solution of problems — divergence to generate plentiful ideas, and convergence to work towards one solution.

2.4.3 Adaption - innovation

The adaption-innovation scale (Kirton, 1987) is a more recent attempt to define a cognitive style manifesting in creativity, problem-solving and decision-making behaviour related to business studies. Kirton has postulated that, when confronted with a problem *adaptors* typically rely upon conventional procedures together with the consensus of their group. This can be seen as a refinement of existing methods, or doing things *better*. On the other hand, *innovators* characteristically attempt to

restructure the problem by approaching it from a new angle, which can be described as doing things *differently*.[4] Kirton states that, compared with adapters, the characteristics of innovators are

- flexibility
- more tolerance of ambiguity
- less dogmatic
- less conservative; more risk-taking

In these respects, innovators seem to have much in common with the diverger.

2.4.4 Intuition

In addition to divergent associations, designers may also call upon insight or intuitive qualities in their thinking. Divergent, creative people may, for example, risk an intelligent guess when faced with a problem, whereas highly convergent thinkers may find the problem insolvable when logic fails to provide a solution. Davies & Talbot (1987) interviewed 35 eminent UK designers[5] at length about the ways in which they design, in order to elicit how they experience moments of insight significant to themselves. How is it that, from the many ideas generated in a problem solving task, the designer knows that a particular proposal is *the* idea that should be taken forward? These designers were strongly persuaded by intuition. A typical response was

> "I always know when an idea is right [but] I can't always put facts and figures against it".

These designers also felt that their intuitive consciousness was impossible to articulate or to translate adequately into language. Several points emerged from this study which are typical of designers' descriptions of their experience of having *the* idea and *knowing* it is right. These may be summarised as

- a sense of wholeness and unity about the solution
- experience of paradox
- difficult or impossible to analyse
- openness to all kinds of experience

4 Doing things *better* or doing things *differently* are management terms introduced by Drucker (1969)

5 Designers were from the faculty of Royal Designers for Industry (RDI), a body of not more than 100 eminent designers selected by the Royal Society of Arts, London. This is a group of creatives drawn from several professions who are distinguished in their fields. They are not all art-based designers.

2.5 Learning styles

Learning style has been defined by Schmeck (1985) as the translation of personality and cognitive style characteristics into study *behaviour*, and by Keefe (1982) as cognitive and affective characteristics that serve as stable *indicators* of how learners perceive and interact with learning environments. From Schmeck's (1985) theoretical perspective, a learning style shows a predisposition on the part of a learner to adopt a particular learning strategy regardless of the specific demands of the learning task. In other words, a style may simply be seen as a strategy that is used with some cross-situational consistency. However, some investigators such as Laurillard (1979) and Entwhistle (1981) have argued that the learning task can override individual predispositions and cause a student who is sensitive to situational demands to adopt a particular strategy for the task irrespective of natural learning style. In spite of a tendency by learners to adopt a certain approach, the coexistence of learning style consistency and variability has been recognised, for example by Ramsden (1992). Learning style can therefore be seen as the *preferred* manner in which an individual processes a specific type of information.

Human beings are highly adaptable and may manage to learn effectively in spite of mismatched teaching. The experiments of Pask & Scott (1972) show however that the rate, quality, and durability of learning is crucially dependent upon the teaching style suiting the individual. Eggins (1979) showed that students who were assessed for learning style learned best when taught with a matching instructional model; Hueser (1991) found that under some circumstances matching imagery with learning style facilitated better transfer; McCaulley (1990), in a review of engineering education, highlighted benefits to learning which can accrue from teaching to style; and Jonassen (1981), in tests of cognitive style in teaching and learning, found that individuals' preferred modes for learning affect perceptions and preferences for the way information should be presented.

In reading, information is not passed from an unbiased author to a passive reader. The meanings derived from information appear to be determined to a significant extent by the worldview of the recipients. Peters (1981) conducted a comprehensive statistical analysis of the matching of different kinds of texts with the preferences of education majors. Students were classified into particular personality types, and texts were then chosen synonymous with these kinds of personality. The texts were studied by the students who reported on their utility from their personal viewpoints. Good correlations were found between type of personality and style of text, together with considerable dislike of materials presented in a *wrong* style. Peters stated

> "Evidently, what one type counts as significant knowledge may be viewed by another as an incoherent jumble of unrelated facts"

Types of personality can play an active, but not exclusive, role in the formation of judgments about information, including the credibility of that information for that individual.

2.5.1 Verbal and visual strategies

The dominance of verbal influences upon thinking has been challenged. Williams (1986) suggested that for individuals to have the maximum opportunity to learn, teaching methods should balance verbal thinking with visual strategies. Similarly, in teaching freehand drawing, Edwards (1979) has developed a number of techniques for encouraging mental shifts from left brain verbal, logical thinking to a right brain, more intuitive mode which facilitates direct access to the right hemisphere's imaging and spatial characteristics. These techniques have been empirically tested with encouraging results. Arnheim (1970) demonstrated that thought processes rely heavily on non-linguistic symbol systems: he saw vision as the sensory system which underpins our cognitive processes, and claimed that

> "truly productive thinking in whatever area of cognition takes place in the realm of imagery".

Eisner (1985) proposed that skills learned in art are important in more general thinking. He states that artistic tasks develop an ability to judge, to assess, and to

> "experience a range of meanings that exceed what we are able to say in words"

This view is considered to be important by designers themselves (Davies & Talbot, 1987). Cross (1982) suggested that there is extensive use of non-verbal modes of thinking in design, which is particularly evident in the designer's use of models and codes that rely so heavily on graphic images.

Learning styles with a strong visual approach have been particularly noted among American Indian and Alaskan native students (Swisher & Deyhle, 1987, 1989). In tests of sentence-picture comparison MacLeod, Hunt & Matthews (1978) found that individuals relatively high in spatial ability chose to use a visual strategy for problem solving, while those relatively high in verbal ability used verbal strategies.

2.5.2 Syllabus-free and syllabus-bound

The contrasting orientations of two well defined groups of learners were reported by Hudson (1968). Individuals who are comfortable with a rigid academic syllabus were termed *syllabus-bound*. Syllabus-bound students perform well in university study, but when engaged in individual project work, do less well. They have similarities with the converger and may exhibit dogmatism. Those individuals who preferred more freedom were termed *syllabus-free*. Syllabus-free students do less well in university, but are less cautious and practical. Josephs & Smithers (1975) have likened the attitude of the syllabus-free student with that of the diverger. In studying preferences for learning, Parlett (1969) found that syllabus-bound students need deadlines and course guides, whereas syllabus-free students prefer some autonomy.

2.5.3 Holists and serialists

Another type of strategy first identified in the context of a learning task (Pask, 1969; Pask & Scott, 1972) delineates *serialists* and *holists*. A serialist typically approaches the learning, remembrance and recapitulation of a new corpus of information by linking together a *sequence* of identified cognitive structures. Lengthy strings of information are sometimes assimilated in this way in order to build up a total picture of the material. Alternatively, holists prefer to learn,

remember and recall information as a *whole.* They attempt to gain an overview of the material in the expectation that details will fall into place and be understood.

Pask & Scott (1972) have shown that the serialists' strategy of assimilating lengthy sequences of data appears to impose an appreciable demand on memory, which in turn makes them less tolerant of redundant information. Serialists are prone to remembering details but failing to grasp the whole. For example, in the learning of a fabricated taxonomy, some students who accumulated all the relevant data subsequently failed to reconstruct the entire taxonomy. Pask & Scott have also shown that, when given a serialist programme, serialists show a remarkable tendency to preserve the ordering of concepts and frames.

Many instances of holistic thinking have been reported historically both from the sciences and the arts, especially in relation to problem solving or other creative endeavours. One of the most famous is Mozart's (1789) letter

> "provided I am not disturbed[...] the whole, though it be long, stands almost complete and finished in my mind, so that I can survey it, like a fine picture or a beautiful statue, at a glance. Nor do I hear in my imagination the parts successively, but I hear them, as it were, all at once (gleich alles zusammen)"

The holists' strength is that they see the whole picture. Pask & Scott (1972) have shown, however, that they may have difficulty in separating out the parts. Holists exhibit disrespect for the inherent ordering. When presented with a holist programme, the serialist finds it difficult to preserve the complete order, but does manage to preserve sequentially arranged fragments.

The ability of learners to change strategy has also been investigated. Pask (1976) identified learners who are as likely to adopt holist strategies as serialist ones: he termed these *versatile* learners. In a study of visual tasks Cooper (1982) found that subjects utilised two basic strategies termed *holistic* and *analytic*. Holistic subjects are able to adopt an analytic mode when the tasks draw upon analytical abilities. However, analytic subjects have extreme difficulty in adopting a holistic mode and when forced to, they perform less efficiently than holistic thinkers.

2.6 Teaching and learning

There are many aspects of the relationship between lecturer and student which affect the delivery, comprehension and retention of learned material. Parlett et al. (1988) conducted structured interviews with typical undergraduate students. Students' comments recorded by this study reveal much dissonance between themselves and their lecturers. For example, confusion is caused by a lecturer who talks too fast for comprehension

> "It was all meat [...] it was too intense; you couldn't remember anything; it was like going in and reading a book [...] I was completely drained."

Learning can get out of step with the linear regularity of teaching, especially where it is assumed that each lecture was fully comprehended at the time.

> "You know a little at the beginning, then you know less and less"
> "we sit there hoping something will go click"

As time passes the problem increases.

> "You can't say 'I haven't followed anything after your third lecture' "
> "you daren't say you've just been muddling through"

Learning is characterised by these students as an iterative process: they drew various images.

> "There are multifarious threads that have to be drawn together"
> "There are things you cannot get — then, six weeks later, after some more lectures, one asks why one couldn't have seen it before — it is so simple"

Parlett et al. conjecture that the general disposition of teaching is a linear process, a succession of evolving presentations for reasons of efficiency of delivery and, perhaps more importantly, organisationally. Considerable variations exist between tutor and student, and several aspects of mismatch are apparent: the style of delivery may not match students' particular needs. One important theme is the lack of control which the student has over the pace of learning from lectures.

2.6.1 Teaching and learning design

A report of the Council for National Academic Awards (CNAA, 1992) showed project based teaching to be the primary vehicle for design studies. Projects

represent the major part of the timetable in the latter part of undergraduate courses[6]. Typically, a project briefing may be followed by a timetable of events during which students are generally left to work at their own pace in collecting information and in formulating ideas[7]. There is sometimes an interim critique at which there is discussion of the work to date. The project usually culminates in a final critique and formal assessment. There is a strong tradition of group critique, emanating from the earlier art schools, where the individual students present their work to their cohort and to tutors, and have an opportunity to respond to questions. The CNAA report states however that this pattern is changing, driven partly by the modularisation of studies, by larger group sizes (often taught by lectures), and by new methods of study such as open learning.

Cross (1985) has suggested that in design education, problems of style mismatch between teacher and learner may be masked by the nature of design teaching itself. The project based character of design teaching may allow sufficient freedom to resolve cognitive mismatches between teacher and learner and provide opportunities for confronting any potential differences of approach between students and their tutors. Skilled teachers are able to change their position and be adaptable in presentation in order to get their point across. A student has frequent opportunities to ask questions in order to develop understanding.

Many factors are interrelated but often the differences lie in individual variations, and preferences in personality and in cognitive domains. Lovell (1989) summed it up as follows

> "If there is one theme that clearly emerges it is that there can be no easy straightforward generalisations about the needs and characteristics of the adult learner. Each individual is unique and his learning will be most effective when his personal strengths and weaknesses are taken into account"

6 In 1993, I analysed documentation from typical industrial design undergraduate courses at three UK universities. A detailed analysis of the timetables showed that the majority of teaching is project based, but the proportion of project teaching (in studio and workshop) rises markedly across the three years. In the final year, projects account for over three quarters of the students' time, and most of the remaining time is taken up with a dissertation (during the first term). In the final term nearly all time is given over to project work (largely workshop time).

7 There are some exceptions eg. design management, design theory courses, and various modular pathways.

2.7 Conclusion

Some components of designers' creative personality and cognitive preferences are beginning to emerge. From studies of brain lateralisation we can see that designers may tap right-brain resources. These resources are characterised by imagination; pictorial and spatial modes of thinking; and a holistic and synthetical approach which seeks patterns and relationships. Further clues are provided by the incidence of left-handedness in architects, and the accuracy of their skills exhibited in a spatial task.

Many kinds of professional are creative, but the designer's particular brand of originality seems more connected with divergent thinking (coupled as it is with ideation and unusual associations) than it does with convergent thinking. Designers' imaginative thinking contrasts sharply with the more practical convergency and other analytical modes. It seems that convergent thinking emanates from a different kind of personality to designers and is, for example, employed typically by engineers. Another important aspect of design thinking is intuition. This is more than guesswork — it centres on a synthetical process, poorly understood and difficult to verbalise, yet which is strongly felt by designers. Eminent designers have reported that they *know* intuitively when an idea is the right one.

In learning, there is evidence that individuals view their world in particular ways, and these cognitive preferences are stable and persistent. There are links between divergency and those students who prefer not to be bound by the syllabus, but prefer instead a less structured form of tuition. Learners may change strategies as appropriate to the task in hand, but they have a style which is their *natural* preference and to which they turn firstly in a learning situation. However, some learners find it easier to change their learning strategy than others.

If teaching is presented in an alien style cognitive dissonance may occur together with potential for misunderstanding of the subject. This view is supported by

students' own perceptions of their teachers and of the methods of teaching. In particular, students' comments highlight their discomfort with the forced pace and serial nature of their lectures. An important consideration which arises from this is the student's need to control the pace of study. Teaching materials are preferred if presented in a style that is *natural* to the learner, and there is some evidence that this is a more efficient way of learning.

Design education is predominantly project based. This represents a flexible form of teaching which may compensate for potential dissonance between teacher and learner due to the many opportunities for students to ask questions.

Chapter 3

Styles of designers

3 Styles of designers

3.1 Introduction

From the previous chapter we have seen that individuals have broad preferences for the ways in which they perceive their world. The literature suggests that designers have particular cognitive styles which may be broadly characterised as holistic, imaginative, and intuitive. Though useful as general descriptors, these characteristics do not provide a sufficiently detailed description of designers' cognition, nor of ways in which they learn. There are several psychometric instruments which have the potential for assessment of designers' learning styles and may provide more detailed descriptions.

For the purposes of this investigation, two distinctly different types of instrument may be considered

- learning style instruments
- personality instruments

3.1.1 Performance criteria

It is required that any instrument conform to the following criteria

- have a sound theoretical basis
- demonstrate evidence of reliability (ie. obtain consistent results)
- be well validated (ie. accomplish what it is intended to do)
- be able to differentiate designers from others
- be associated with a large corpus of results which are consistent, and clearly show differences between occupational groups (including designers if possible)
- be associated with well defined *teaching* and *learning* styles which are capable of computer implementation
- be in a form which could be implemented practicably on a CAI system to classify individual learners
- have valid and useful correlations with other psychometric scales

3.1.2 Learning style instruments

There are several instruments which assess learning styles and which offer pointers to appropriate teaching methods. In reviews of the literature, Gorham (1986) found learning style inventories to be less robust than personality instruments due mainly to theoretical or practical weaknesses, and Bonham (1988) has pointed to learning style theories having a more practical orientation than earlier cognitive theories, though they have shorter research histories. Following a comprehensive review of the literature I concluded that learning style instruments do not generally match the criteria listed above. In particular, styles of teaching and learning are often described vaguely and would be difficult to implement without considerable creative interpretation. Additionally, for some instruments, there are few data on reliability or validity.

One such example of a popular learning style instrument is the Kolb LSI discussed in chapter 1 (cf. 1.5.4). This instrument arises from Kolb's theoretical *Experiential Learning Model* (ELM)[1], and is widely used in educational research and student counselling (Kolb, 1984). However, from the early 1980s onwards both the theory and the instrument have attracted considerable criticism. In particular, Freedman & Stumpf (1980) and Stumpf & Freedman (1981) asserted that most early empirical evidence for the ELM was based on the results of unpublished studies; that the LSI does not correlate reliably with its underlying theory; and that the LSI has low test-retest reliability. They concluded

> "Judged by accepted academic standards, the LSI is an instrument that, if used on an individual learning basis, will result in excessive unreliable and invalid inferences on the part of the user."

In Kolb's (1981) rebuttal of this criticism, he accepted that variability is central to the instrument but excused this as being intrinsic to the underlying theory. Furthermore he suggested that results should be used by the individual only as a starting point for purposes of self-examination and understanding of their particular learning style. He specifically rejected any notion that the instrument can detect

1 The Experiential Learning Model perceives learning as a four-stage process ranging from concrete experience, through reflection and conceptualisation/abstraction, finally to active experimentation. The Kolb LSI classifies four kinds of individual derived from polar opposites on two scales. These are termed converger; diverger; assimilator; and accommodator.

fixed traits. In the face of criticism, a modified version of the LSI was published in 1985. Stout & Ruble (1994), in reviewing evidence for the reliability of the instrument in accountancy education research, have focused on the use of the revised (1985) version of the LSI. They identified a number of psychometric problems affecting its reliability and validity. In particular they state

> "it is unwarranted to draw conclusions based on research conducted with the LSI about the existence of characteristic learning styles of accounting students and how they compare to those of other academic majors, accounting practitioners, and students in other countries."

They conclude

> "We find no empirical support for the validity of the LSI-85 [...] thus we recommend suspension of the use of this instrument in accounting education research."

On balance, this instrument does not meet many of the suitability criteria as outlined in 3.1.1 above.

3.1.3 Personality instruments

Alternatively, personality instruments do not specifically identify learning styles but seek to determine underlying mind sets which become visible as personality characteristics (Lawrence, 1982). Gorham (1986) points out that many of these instruments are reliable and well validated, and that some have a long history. Some personality instruments have a substantial theoretical underpinning, and also have the advantage of comparative data and correlations with other psychological scales. Styles of learning can also be related to some personality instruments, either by correlations with other scales or by observational data.

3.2 Psychological types

The *Theory of Psychological Types* proposed by the Swiss psychiatrist Carl Jung (1921) states that people exhibit basic preferences in the ways they use their minds, and that these differences between individuals influence the ways they like to work, what motivates them, and what satisfies them. He found these patterns of basic behaviour to be predictable, stable, and rooted in the ways people *prefer* to use their minds. As soon as children exercise a preference for one mode or the other, their development is towards the preferential *enjoyment* of one mode rather than

the other. Jung (1954) proposed that type theory exposes these patterns and provides an explanation of how psychological types develop.

3.2.1 MBTI

Jung's theory has been operationalised in the *Myers-Briggs Type Indicator* (MBTI). The MBTI was developed by Katherine Briggs and her daughter Isabel Myers from about the time of World War 2. It is today probably the most widely used psychometric instrument for non-psychiatric purposes, and is extensively used in counselling, self-development, and management training (Myers & Myers, 1980; Myers, 1993). Durling (1994, 1995) has proposed the instrument as a robust tool for mapping cognitive styles to human-computer interfaces, and for classifying the styles of designers and others. The MBTI is a self-reporting instrument comprising upwards of 50 forced-choice questions, depending upon the version being used. Questions are based on a choice of two answers, and are generally of the form

which word in the pair below appeals to you more
- facts?
- ideas?

when you go somewhere for the day, would you rather
- plan what you do and when?
- just go?

in your daily work, do you
- rather enjoy an emergency that makes you work against time?
- usually plan your work so you won't need to work under pressure?

It would be possible to implement a form of the instrument on a computer as part of a CAI system which assesses for style[2].

3.2.2 Robustness

The MBTI has links to empirical observations of learning styles and correlations with other psychological scales (Myers & McCaulley, 1985). The Center for Applications of Psychological Type (CAPT), Florida, maintains a database, the *Atlas of Type Tables* (Macdaid, McCaulley & Kainz, 1986), of persons who have been assessed by the MBTI over the past 30 years. Nearly 60,000 with usable

2 This might be achieved either with the AV form of the MBTI (Myers & McCaulley, 1985), or with the Keirsey *sorter* (Keirsey & Bates, 1985). These are both shortened questionnaires and more suitable for this purpose.

occupational codes are published from a total of over 230,000.

There is much evidence of the reliability and validity of the MBTI, and its suitability for the task of this thesis. A critical review published in the *Buros Mental Measurements Yearbook* (1989) casts some doubt on the stability of type classification over time, although it is positive about the instrument's validity

> "The MBTI is an excellent example of a construct-oriented test that is inextricably linked to Jung's (1923) theory of psychological types [...] it is held in high regard by many who subscribe to this aspect of Jungian theory. [There exists] a considerable body of evidence regarding the validity of the MBTI"

Similarly, in viewing the four scales of the MBTI separately, the review continues

> "there is a wealth of external validity information presented in the extensive manual (actually a handbook) that provides a reasonably consistent picture of what the individual scales do and do not measure" (parentheses are in the original text).

Having regard to the criteria (set out in 3.1.1) above, the MBTI is a practicable and appropriate instrument in the context of this study[3].

3.2.3 Scales

In assessing preference strengths which reflect the kinds of judgments and perceptions individuals use in interacting with their environment the MBTI exposes several constructive differences between people. A central philosophy of the instrument is that it aims to be neutral: all types are equal. It does not detect psychopathologies or traits such as neuroticism. The MBTI classifies 16 individual psychological types. These are based upon the following dichotomised scales which closely follow and develop Jung's theory.

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3 For a detailed discussion of construct validity and the many correlations with other scales see Myers & McCaulley (1985). Test/retest reliability is high, and the instrument has had a long development period. However, it does have its critics, for example in not measuring some of the more undesirable characteristics of personality such as neuroticism. See Pittenger (1993) for a systematic and wide ranging critical appraisal. There are also more modern theories of personality: the past decade or so has seen the emergence of a Five Factor model (5FP) of personality which seeks to address, among other things, the apparent shortcomings of psychological type theory. See McCrae & Oliver (1992) for a complete review of the literature, and McCrae & Costa (1989) for correlations between the 5FP model and the MBTI: they have made a case for remapping the MBTI scales to the 5FP. However, the 5FP constitutes a relatively new model at present under development, and there is scant evidence of related learning style preferences which would be of practical use in the context of this study. In any case, if the general approach of using a robust personality instrument (as against a learning style instrument) is valid, then any other appropriate model of personality might be substituted.

Orientation	EXTRAVERSION • INTROVERSION
Processes	SENSING • INTUITION
	THINKING • FEELING
Attitudes	JUDGMENT • PERCEPTION

Figure 3.1: MBTI scales (mental processes are shown tinted)

Key aspects of the MBTI scales will now be explained in some detail[4].

3.2.4 Orientation

Orientation comprises the scale of EXTRAVERSION•INTROVERSION[5]. The independent preferences for EXTRAVERSION and INTROVERSION determine the context of an individual's relation to their outer and inner worlds.

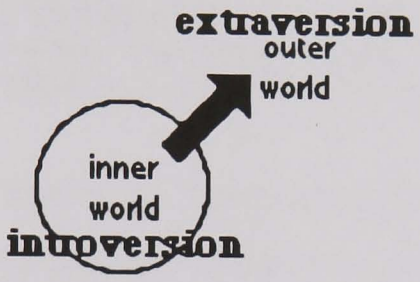

Figure 3.2: Orientation *(adapted from the MBTI)*

The main interests of those preferring EXTRAVERSION are in the outer world of people and things. EXTRAVERSION types tend to do their best work externally, in action. Conversely, the INTROVERSION types' main interests are in the inner world of concepts and ideas, so they prefer to focus more upon ideas. INTROVERSION types do their best work reflectively, in their heads.

EXTRAVERSION • INTROVERSION	
How a person prefers to focus attention	
EXTRAVERSION relates to the outer world of action with people and things: those preferring EXTRAVERSION are comfortable with other people and prefer to work in groups.	INTROVERSION relates to one's own inner world of ideas and concepts: those preferring INTROVERSION are comfortable when working quietly alone.

Figure 3.3: EXTRAVERSION and INTROVERSION (adapted from the MBTI)

4 The use of specialised terms should be noted. It is important to realise that all of these descriptive terms are used in the sense *intended by Jung* in his theory of psychological types as interpreted in the MBTI instrument. This specialised use of certain terms may sometimes seem counter intuitive or run counter to colloquial usage. These specialised terms are denoted by SMALL CAPITALS. The terms EXTRAVERSION, INTROVERSION, SENSING, INTUITION, THINKING, FEELING, JUDGMENT, and PERCEPTION when in small capitals, are used **only** with these specialised meanings.

5 Of all the descriptors these are perhaps the most misunderstood. Those preferring EXTRAVERSION are not simply outward-going, and those preferring INTROVERSION are not timid... but they might be...

3.2.5 The processes

The processes comprise two ways of taking in information and coming to conclusions about the information so received. In mental processing, individuals are involved in one of two mental activities

- *taking in* information — an act of information *collection*
- coming to *conclusions* about that information — an act of *decision*

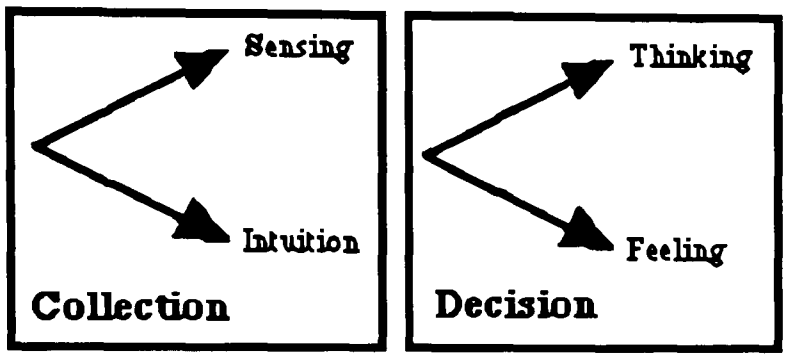

Figure 3.4: Mental processes: collection and decision modes (adapted from the MBTI)

There are two opposite modes of information *collection*, termed SENSING and INTUITION. SENSING is where we become aware of things experienced directly through the five senses. This kind of information gathering therefore attends to directly observable phenomena and facts. SENSING focuses on the present or past.

On the other hand, INTUITION is a form of indirect information gathering by way of the unconscious mind. Ideas or associations are added to more direct information, and these unconscious contributions range from hunches through to visionary and creative approaches. Imagination is brought into play to explore possibilities, and this gives INTUITION a focus more toward the future.

SENSING • INTUITION	
How a person takes in information	
SENSING is perceiving reality directly through the senses, dealing with the practical elements of reality and facts. It is focused on what is actual, in the present or past.	INTUITION is internal SENSING using imagination, seeking possibilities, preferring relationships and problems to facts. It is focused on what might be, in the future.

Figure 3.5: SENSING and INTUITION (adapted from the MBTI)

There are also two sharply contrasting ways of coming to conclusions, or deciding, about the information which is collected. This is termed THINKING and FEELING. THINKING is a logical decision process which acts impersonally, in a detached way. Alternatively, FEELING is a decision process which acts by appreciation, and utilises more personal, subjective values.

THINKING • FEELING	
How a person makes decisions	
A thinking preference is characterised by analytical, logical, evaluative and objective modes of thought: this is an impersonal basis for choice.	Feeling people are more subjective, utilise sympathy and empathy, and prefer to weigh personal values. Choices are made by personalising considerations.

Figure 3.6: THINKING and FEELING (adapted from the MBTI)

3.2.6 The attitudes

A significant addition to Jung's theory was made by Briggs and Myers in the form of a fourth scale. This concerns the *attitude* taken toward the outer world. When a decision process (THINKING or FEELING) is used in running the outer life the natural preference is toward having things settled, decided, organised, and planned. This is termed a JUDGMENT[6] attitude. If, however, a collection process (SENSING or INTUITION) is used to run one's outer life the natural preference is more towards keeping oneself open to new perceptions, to experience life as widely as possible, and to be flexible in adapting to changing circumstances. This is termed a PERCEPTION attitude. The JUDGMENT • PERCEPTION preference points to the process used in the EXTRAVERSION attitude (ie. the outer world) for both EXTRAVERSION types and INTROVERSION types.

JUDGMENT • PERCEPTION	
How a person deals with the outer world	
JUDGMENT emphasises thinking in a decisive, planned and orderly manner, aims to control events, and is associated with closure and the settling of things.	PERCEPTION is more about keeping options open, and is associated with living a more flexible, spontaneous existence, aiming to understand life and adapt to it.

Figure 3.7: JUDGMENT and PERCEPTION (adapted from the MBTI)

6 Note that this does not mean judgmental.

3.2.7 Types

Although the MBTI can discriminate between 16 types, there are many subgroups which may be arranged for various purposes. Starting with combinations of the four processes, the build up of the types is as follows. Combinations of the 2 processes scales produce 4 basic types.

Types are denoted by the lead letters of the scales

E•I (EXTRAVERSION or INTROVERSION)

S•N (SENSING or INTUITION)[7]

T•F (THINKING or FEELING)

J•P (JUDGMENT or PERCEPTION)

SENSING		INTUITION	
with THINKING	with FEELING	with FEELING	with THINKING
ST	**SF**	**NF**	**NT**

Figure 3.8: 4 psychological types

The processes are then independently acted upon by the orientation scale of EXTRAVERSION and INTROVERSION. This produces 8 types.

	SENSING		INTUITION	
	with THINKING	with FEELING	with FEELING	with THINKING
INTROVERSION	**IST**	**ISF**	**INF**	**INT**
EXTRAVERSION	**EST**	**ESF**	**ENF**	**ENT**

Figure 3.9: 8 Jungian psychological types

Lastly, the 8 types are influenced by the attitude scale JUDGMENT • PERCEPTION, which provides a total of 16 identified types denoted by a 4 character label.

7 N: as 'I' is already used for INTROVERSION, 'N' denotes INTUITION.

		SENSING		INTUITION	
		with THINKING	with FEELING	with FEELING	with THINKING
INTROVERSION	with JUDGMENT	**ISTJ**	**ISFJ**	**INFJ**	**INTJ**
	with PERCEPTION	**ISTP**	**ISFP**	**INFP**	**INTP**
EXTRAVERSION	with PERCEPTION	**ESTP**	**ESFP**	**ENFP**	**ENTP**
	with JUDGMENT	**ESTJ**	**ESFJ**	**ENFJ**	**ENTJ**

Figure 3.10: 16 MBTI psychological types (adapted from the MBTI)

The dynamic interaction of the Jungian scales lend to each type a number of significant characteristics. This is not to say that all members of a type category are the same. Indeed, due to many external influences in development towards adulthood there will be a wide variation in interests and vocations within any type category. But the members of that type will share certain basic characteristics. Jung wrote of the types

> "From these combinations well-known pictures arise, the practical intellect for instance paired with sensation, the speculative intellect breaking through with intuition, the artistic intuition which presents its images by means of feeling judgment, the philosophical intuition which, in league with a vigorous intellect, translates its vision into the sphere of comprehensible thought, and so forth".

Jung's descriptions of the types was brief but intended to convey the basic differences that determine what individuals will prefer and will focus upon. Both preferences of one scale will be used by an individual, but one preference will have natural precedence over the other. Although some people will have stronger preferences than others, most will exhibit some degree of preference at both ends of the scale. Therefore there is a tension between the preferences, stronger in some, weaker in others. Additionally, the extent to which a given preference is used will depend upon the task: for example, in problem-solving we might assemble the facts and assess the present position in SENSING mode, but then switch to INTUITION mode to make plans about future possibilities. Similarly, a THINKING mode may be suitable for a problem which may be addressed in a step-by-step logical manner, whereas a FEELING mode might be more suitable when dealing with

issues concerning people or human values. People will flip to and from the modes suitable for the task in hand, but they retain their basic preferred mode to which they *naturally* turn firstly when considering a task.

3.3 Repositioning of types

The conventional MBTI matrix (as shown in Figure 3.10) is useful in logically describing the combinations of scales which make up the 16 psychological types. Myers had however stated that combinations of the 4 mental *processes* (cf. Figure 3.1) would prove most important for education. These are shown by the middle letters on the MBTI profile: ST, SF, NT, or NF. Within the conventional MBTI matrix the types are conveniently positioned to reflect the 4 processes (SENSING • INTUITION and THINKING • FEELING) influenced firstly by

- the EXTRAVERSION•INTROVERSION scale, and secondly
- by the JUDGMENT•PERCEPTION scale

This aids understanding of the interplay of the 4 scales. In the context of this investigation, it will be useful to reposition the types as explained below.

3.3.1 Dominance

Within each type the 4 processes are ranked in order of preference of use, from the most preferred (or *dominant*) to the least preferred (or *inferior*) (Myers & McCaulley, 1985). The ranking of the processes is as follows

- **dominant** (most preferred) this is the process which is naturally used firstly.
- **auxiliary** (2nd preference) this process is used in conjunction with the dominant, but is used secondly
- **tertiary** (3rd preference)
- **inferior** (least preferred) the inferior process is the least used

This ranking represents the order in which an individual will naturally turn to their

mental resources. The dominant process represents the primary view through which the individual's world is sensed and handled. For example, an ENTP would have a view dominated by INTUITION, whereas an INTP would prefer to primarily utilise THINKING. On the other hand the shadow side of personality is that which is opposite our natural preferences, and comprises the tertiary process and especially the inferior process. The shadow is the side that individuals do not often express. For example, if a person prefers INTUITION with THINKING dominant (NT), the shadow will be SENSING and FEELING (SF). In this case, FEELING will be the least preferred process and the individual may be uncomfortable with its usage or ignore it altogether.

The underlying ranking of preferences is as follows[8]. For each psychological type, the mental processes are shown ranked from the most preferred (dominant) to the least preferred (inferior).

Type	Dominant	Auxiliary	Tertiary	Inferior
	<< most preferred			least preferred >>
ISTJ	SENSING (S)	THINKING (T)	FEELING (F)	INTUITION (N)
ISFJ	SENSING (S)	FEELING (F)	THINKING (T)	INTUITION (N)
INFJ	INTUITION (N)	FEELING (F)	THINKING (T)	SENSING (S)
INTJ	INTUITION (N)	THINKING (T)	FEELING (F)	SENSING (S)
ISTP	THINKING (T)	SENSING (S)	INTUITION (N)	FEELING (F)
ISFP	FEELING (F)	SENSING (S)	INTUITION (N)	THINKING (T)
INFP	FEELING (F)	INTUITION (N)	SENSING (S)	THINKING (T)
INTP	THINKING (T)	INTUITION (N)	SENSING (S)	FEELING (F)
ESTP	SENSING (S)	THINKING (T)	FEELING (F)	INTUITION (N)
ESFP	SENSING (S)	FEELING (F)	THINKING (T)	INTUITION (N)
ENFP	INTUITION (N)	FEELING (F)	THINKING (T)	SENSING (S)
ENTP	INTUITION (N)	THINKING (T)	FEELING (F)	SENSING (S)
ESTJ	THINKING (T)	SENSING (S)	INTUITION (N)	FEELING (F)
ESFJ	FEELING (F)	SENSING (S)	INTUITION (N)	THINKING (T)
ENFJ	FEELING (F)	INTUITION (N)	SENSING (S)	THINKING (T)
ENTJ	THINKING (T)	INTUITION (N)	SENSING (S)	FEELING (F)

Figure 3.11: Ranking of processes, dominant to inferior (adapted from the MBTI)

Lawrence (1982) has argued that ranking of the processes, particularly the influence of the dominant process, is most significant in applying learning styles to the individual MBTI types. Therefore, in attempting to systematically map learning styles to the MBTI classification, I have taken the opportunity to prioritise

8 For a full description of the ranking of preferences see Myers & McCaulley (1985).

and reposition the types within a matrix which reflects the influence of dominance and the ranking of the mental processes.

In the horizontal axis, the position of types is determined by ranking as follows

- SENSING to the left
- INTUITION to the right

Within this new ranking (of SENSING and of INTUITION)

- JUDGMENT to the left
- PERCEPTION to the right

In the vertical axis, the position of types is determined by ranking as follows

- THINKING to the top
- FEELING to the bottom

These may therefore be usefully mapped to the matrix as follows

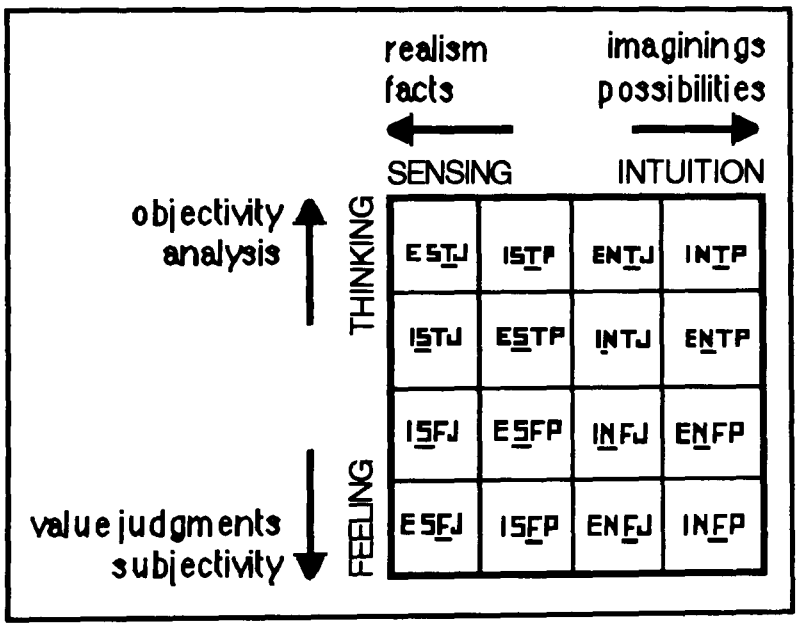

Figure 3.12: General scheme of repositioned types

3.3.2 Preferences

Additionally, following what we know of preferences associated with the mental processes (cf. 3.2.5) basic preferences may also be mapped to this matrix as follows

- SENSING types prefer
  reality and facts
- whereas INTUITION types prefer
  imagination and possibilities

- THINKING types prefer
  objectivity
  logical analysis
- whereas FEELING types prefer
  subjectivity
  personal values

Further details of this repositioning are provided in chapter 5 which covers the advantages of the revised typology, together with the uses that can be made of it in the context of a computer implementation of learning styles. It is this revised matrix which will be used in all examples throughout the rest of this thesis.

3.4 Samples of psychological types

In any given occupational group it is likely that all 16 types will be found, though many occupations tend to cluster around certain groups of types. For example it might be expected that police, who are persuaded by evidence, would inhabit those types where SENSING is a strong preference, whereas vicars might be expected to be types where FEELING values dominate[9]. Some examples of psychological types in design-related and other occupations are shown below. Most of these are extracted from MBTI data published in the *Atlas of Type Tables* (Macdaid, McCaulley &

9 ...and this is supported by the data. *Atlas of Type Tables* (Macdaid, McCaulley & Kainz, 1986) ref. 8629442 police and detectives (SENSING = 85%); and ref. 8629395 clergy, all denominations (FEELING = 78%).

Kainz, 1986).

3.4.1 Presentation of data

In an effort to visualise the data more easily, a darker tone denotes more individuals in that particular group, on the following basis.

Figure 3.13: Distribution percentages

Each type box shows the type; the percentage of subjects of that type; and the frequency of subjects in parentheses.

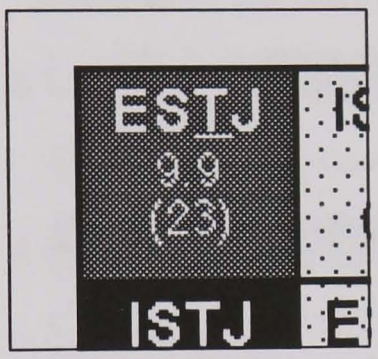

Figure 3.14: Type, percentage, and frequency (in parentheses) in type diagrams

3.4.2 Population norms

The *Atlas* data relate mainly to a USA population. Although a wide range of occupations is listed it is thought that, due to the origins of the MBTI, the total population shown in the CAPT database is skewed toward the academic. However, there are data relating to a random sample of population arising from one particular study[10]. This sample is used here as an indication of a general population for purposes of comparison[11] (Myers & McCaulley, 1985).

10 Data collected by Brooke Warrick of SRI International during the summer of 1983. The subjects were 1105 people in a random national sample of households. Reported in *Atlas of Type Tables* (Macdaid, McCaulley & Kainz, 1986) ref. 8631305.

11 The sample is thought to be the closest currently available on a nationwide random basis, but it wholly relates to a USA population, and is perhaps somewhat biased toward more affluent groups.

ESTJ 9.9 (110)	ISTP 6 (67)	ENTJ 3.9 (43)	INTP 2.1 (23)
ISTJ 19.1 (211)	ESTP 4 (44)	INTJ 3.3 (36)	ENTP 2.1 (23)
ISFJ 15.6 (172)	ESFP 5.4 (60)	INFJ 3 (33)	ENFP 3.7 (41)
ESFJ 9.1 (101)	ISFP 6.7 (74)	ENFJ 2.3 (25)	INFP 3.8 (42)

Figure 3.15: General population (n=1105)

It will be noted that there is an uneven distribution of type. Distributions of the orientation, mental processes, and attitudes are as follows.

Orientation (EXTRAVERSION • INTROVERSION)

E 40% | 60% I

Processes (SENSING • INTUITION and THINKING • FEELING)

S 76% | 24% N

T 50% | 50% F

Attitudes (JUDGMENT • PERCEPTION)

J 66% | 34% P

In the context of what will be stated about designers below, it should be noted that in a general population

- 24% prefer INTUITION (N)
- 34% prefer PERCEPTION (P)

Therefore we can see that a general population may comprise

mostly SENSING types
mainly JUDGMENT types

3.4.3 Designers

Only a small sample of designers is listed in the *Atlas of Type Tables*. However, the definition of designer is not confined to art-based design, and it is thought that

this sample may comprise mainly draftspersons or possibly engineering designers[12]. The data are therefore not reported here. There are several other samples of professions which can be thought of as related to design. Results from some of these professions will be discussed.

3.4.4 Architects

There are adequate data on architects, principally stemming from MacKinnon's (1962) celebrated study of American architects in the sixties[13]. The study compared 3 groups of architects ranging from ordinary architects to those judged to be at the peak of their profession. The data below refer firstly to the combined sample of 124 subjects, and secondly to the sample of 41 highly creative architects[14].

ESTJ 5.6 (7)	ISTP 0 (0)	ENTJ 6.4 (8)	INTP 12.1 (15)
ISTJ 7.3 (9)	ESTP 0 (0)	INTJ 20.2 (25)	ENTP 4.8 (6)
ISFJ 3.2 (4)	ESFP 0 (0)	INFJ 9.7 (12)	ENFP 6.4 (8)
ESFJ 0.8 (1)	ISFP 0.8 (1)	ENFJ 5.6 (7)	INFP 16.9 (21)

ESTJ 0 (0)	ISTP 0 (0)	ENTJ 4.8 (2)	INTP 24.4 (10)
ISTJ 0 (0)	ESTP 0 (0)	INTJ 17 (7)	ENTP 4.8 (2)
ISFJ 0 (0)	ESFP 0 (0)	INFJ 7.3 (3)	ENFP 14.6 (6)
ESFJ 0 (0)	ISFP 0 (0)	ENFJ 9.7 (4)	INFP 17 (7)

Figure 3.16: Representative architects (n=124) and highly creative architects (n=41)

For the representative architects it will be noted that

- 82% prefer INTUITION (N)
- INTUITION (N) is combined with more THINKING (T) than FEELING (F)
- 70% prefer INTROVERSION (I)

For the highly creative architects it will be noted that

12 *Atlas of Type Tables* (Macdaid, McCaulley & Kainz, 1986), sample of occupation: designer, ref. 8629401.

13 *Atlas of Type Tables* (Macdaid, McCaulley & Kainz, 1986), data collected by Donald MacKinnon at the Institute of Personality Assessment and Research, University of California, Berkeley, during 1961, ref. 8623101.

14 These were judged to be highly creative by a rigorous expert peer review process, and included many important American architects of the period. The MBTI was included in a battery of tests to determine aspects of creativity.

• **all** prefer INTUITION (N). This compares to only 24% in a general population.

INTUITION (N) is the dominant trait in these individuals, and is mainly allied with THINKING (T). The high creative group also showed higher preference scores for INTUITION (N).

We can therefore conclude that architects are

future oriented, concerned with possibilities
objective

3.4.5 Fine artists

Fine artists are also represented[15].

ESTJ 0.8 (1)	ISTP 0 (0)	ENTJ 8.8 (10)	INTP 10.5 (12)
ISTJ 1.7 (2)	ESTP 0.8 (1)	INTJ 7 (8)	ENTP 0 (0)
ISFJ 2.6 (3)	ESFP 0 (0)	INFJ 16.7 (19)	ENFP 14 (16)
ESFJ 1.7 (2)	ISFP 0.8 (1)	ENFJ 12.3 (14)	INFP 21.9 (25)

Figure 3.17: Fine artists (n=114)

It can be seen that fine artists are

- 91% INTUITION (N)
- 70% FEELING (F)

INTUITION (N) is still the dominant preference[16] in these individuals, but here it is combined more with FEELING (F). 65% combine INTUITION and FEELING (NF).

We can therefore conclude that artists

are future oriented, concerned with possibilities
are more value-centred and subjective

15 *Atlas of Type Tables* (Macdaid, McCaulley & Kainz, 1986), data collected by Robert Simon during April 1978 from artists associated with the Fine Arts Society in San Diego, California, ref. 8623100.

16 Similarly to the architects, of those peer rated as being the most creative, 95% of artists preferred INTUITION.

3.4.6 Interior design majors

A more recent study assessed personality types in interior design majors studying at several universities in the USA (Diehl, 1992)[17].

ESTJ 4.3 (10)	ISTP 3.4 (8)	ENTJ 3.8 (9)	INTP 4.7 (11)
ISTJ 6.4 (15)	ESTP 2.1 (5)	INTJ 4.7 (11)	ENTP 9 (21)
ISFJ 6.4 (15)	ESFP 4.7 (11)	INFJ 4.3 (10)	ENFP 15.8 (37)
ESFJ 7.7 (18)	ISFP 2.6 (6)	ENFJ 9 (21)	INFP 11.1 (26)

Figure 3.18: Interior design majors (n=234)

It will be noted that

- 62% are INTUITION (N)
- 62% prefer FEELING (F)

INTUITION (N) is the main preference in these individuals, and is usually allied with FEELING (F). We can therefore conclude that interior design majors are

mainly future oriented, concerned with possibilities
more value-centred
not as INTUITION as the architectural sample
not as FEELING oriented as the fine artists
more EXTRAVERSION than either architects or artists

In the USA educational system, interior design is perhaps a more technically based subject than its UK counterpart, and is more often taught within a school of architecture. Therefore, their MBTI position relative to architects and fine artists seems consistent with theory.

3.4.7 Types in other occupations

Some other professions differ from design types. For example, business managers, mechanical engineers, and computer professionals often inhabit different areas of the typology.

17 A doctoral dissertation not cited in the *Atlas of Type tables*. There were 234 subjects.

3.4.8 Business managers

A profile for business managers[18] is as follows.

ESTJ 20.7 (176)	ISTP 4.4 (37)	ENTJ 8.8 (75)	INTP 3 (25)
ISTJ 23.8 (202)	ESTP 3.9 (33)	INTJ 6.5 (55)	ENTP 4.2 (36)
ISFJ 6.5 (55)	ESFP 1.2 (10)	INFJ 2.4 (20)	ENFP 2.9 (25)
ESFJ 5.9 (50)	ISFP 1.2 (10)	ENFJ 1.6 (14)	INFP 3 (26)

Figure 3.19: Business managers (n=849)

Business managers are

- 67% SENSING (S)
- 75% THINKING (T)
- 76% JUDGMENT (J)

Objectivity and dealing with facts are the dominant traits in business managers, and this is allied to a decisive attitude. We can therefore conclude that business managers are

present or past oriented
more objective
practical, concerned with facts

3.4.9 Engineers

A profile for mechanical engineers[19] shows the following.

ESTJ 18.2 (14)	ISTP 6.5 (5)	ENTJ 2.6 (2)	INTP 3.9 (3)
ISTJ 19.5 (15)	ESTP 3.9 (3)	INTJ 6.5 (5)	ENTP 9.1 (7)
ISFJ 2.6 (2)	ESFP 0 (0)	INFJ 3.9 (3)	ENFP 3.9 (3)
ESFJ 3.9 (3)	ISFP 3.9 (3)	ENFJ 5.2 (4)	INFP 6.5 (5)

Figure 3.20: Mechanical engineers (n=77)

18 *Atlas of Type Tables* (Macdaid, McCaulley & Kainz, 1986), data of English business managers collected by Charles Margerison and Ralph Lewis at the Cranfield School of Management, UK, ref. 8623109.

19 *Atlas of Type Tables* (Macdaid, McCaulley & Kainz, 1986), sample of engineers: mechanical, ref. 8629463.

Mechanical engineers are

- 70% THINKING (T)
- 62% JUDGMENT (J)

The analytical THINKING (T) mode dominates here and is combined with a decisive attitude. We can therefore conclude that mechanical engineers are

objective
decisive, based upon facts

3.4.10 Computer professionals

A sample of computer professionals[20] is as follows.

ESTJ 9.2 (114)	ISTP 5.2 (64)	ENTJ 8.3 (103)	INTP 12.1 (149)
ISTJ 22.6 (278)	ESTP 2.1 (26)	INTJ 15.5 (191)	ENTP 5.6 (69)
ISFJ 3.9 (48)	ESFP 0.7 (9)	INFJ 2.7 (33)	ENFP 3.4 (42)
ESFJ 1 (12)	ISFP 1.5 (18)	ENFJ 2.4 (29)	INFP 3.6 (44)

Figure 3.21: Computer professionals (n=1229)

Computer professionals are

- 81% THINKING (T)
- 66% JUDGMENT (J)

This shows a wider distribution, although similarly to engineers and business managers a large majority is concentrated towards the upper half of the matrix (cf. 3.4.8; 3.4.9). The analytical THINKING (T) mode again dominates and is combined with a decisive attitude. However, they are more inclined to use their THINKING (T) equally with either SENSING (S) or INTUITION (N). We can therefore conclude that computer professionals are

objective and analytical
just as likely to be future oriented as factual

20 *Atlas of Type Tables* (Macdaid, McCaulley & Kainz, 1986), data on 1229 computer professionals collected by Michael Lyons of NT Systems Corporation from 1982 to 1984. 83% were from the US, and 17% from the UK and Australia. Ref. 8623188.

3.4.11 Military personnel

As military personnel have been associated with successes in the use of computer based training systems it is of interest to compare them with other professionals[21].

ESTJ 11.9 (555)	ISTP 6.2 (289)	ENTJ 4.4 (204)	INTP 3.8 (177)
ISTJ 18.9 (883)	ESTP 4.3 (200)	INTJ 5 (233)	ENTP 5 (235)
ISFJ 8.3 (395)	ESFP 4.1 (192)	INFJ 2.2 (105)	ENFP 6.2 (291)
ESFJ 5.6 (260)	ISFP 5.4 (250)	ENFJ 2.8 (129)	INFP 5.7 (265)

Figure 3.22: Military personnel (n=4663)

Military personnel are

- 65% SENSING (S)
- 60% THINKING (T)
- 59% JUDGMENT (J)

Though this is not as extreme as some other occupational groups it does show a bias towards SENSING (S) mainly with THINKING (T). We can therefore conclude that military personnel are characterised by being

factual
objective and analytical

3.4.12 Ergonomists

The position of ergonomists in the typology is of interest in the context of this study. Ergonomists are often drawn from a number of disciplines (eg. psychology, work study, orthopaedics etc.) the members of which may exhibit certain styles. Ergonomy is not an occupational category listed in the *Atlas*. Amalgamating data from several relevant occupations listed in the *Atlas* proved inconclusive. Therefore it is not known whether ergonomists are similar to designers, nor whether their learning needs will be similar.

21 *Atlas of Type Tables* (Macdaid, McCaulley & Kainz, 1986) ref. 8623157. Subjects were enlisted personnel attending a school in cryptology at a USA naval technical training centre.

3.5 Survey of UK design students

But what of UK design students? British art & design education has its roots in a long established art school system, largely subsumed firstly within the polytechnics and more recently within the university sector. Design has, until quite recently, been taught as a single discrete subject, and has been aimed toward the practice of design. Elsewhere, there has often been a broader approach to design as an academic subject, together with different emphases on the practice of design. Individuals selecting themselves for design studies in the UK may therefore demonstrate a different profile of preferences.

In order to get a feel for where typical UK design students are situated in the MBTI typology, a study[22] of university undergraduates was undertaken in the Spring term of 1995. It must be stressed at the outset that this was a relatively small scale survey intended to show the direction of possible confirmatory evidence.

3.5.1 Establishments

Two universities were selected which offered typical art-based undergraduate design courses in both 2D and 3D studies. Samples were restricted to whole subject-specialist cohorts in their first year of study. First year students were chosen because they are relatively unchanged by their studies. A total of 71 students was assessed. The subject specialisms covered were

- industrial design (product)
- interior design
- graphic design
- furniture design
- design/marketing

22 Detailed results of this survey are recorded in Appendix A.

3.5.2 Method

Following a brief introduction and explanation of the study, a questionnaire was completed by each student. Primary data collected included

- the psychological type indicated
- name, and subject specialism of the student
- date of the survey

3.5.3 Results

The results of this assessment of representative design students is as follows.

ESTJ 4.2 (3)	ISTP 2.8 (2)	ENTJ 9.8 (7)	INTP 5.6 (4)
ISTJ 1.4 (1)	ESTP 2.8 (2)	INTJ 5.6 (4)	ENTP 26.8 (19)
ISFJ 1.4 (1)	ESFP 7 (5)	INFJ 2.8 (2)	ENFP 15.5 (11)
ESFJ 0 (0)	ISFP 1.4 (1)	ENFJ 5.6 (4)	INFP 7 (5)

Figure 3.23: Representative design students (n=71)

The scales are as follows.

Orientation (EXTRAVERSION • INTROVERSION)

Processes (SENSING • INTUITION and THINKING • FEELING)

Attitude (JUDGMENT • PERCEPTION)

It will be noted that

- 79% are INTUITION (N) and this is combined with more THINKING (T) than FEELING
- 72% prefer EXTRAVERSION (E)
- 69% prefer PERCEPTION (P)
- 26% are of one type (ENTP)

INTUITION (N) is preferred by these individuals, and is mainly allied with THINKING (T). They also markedly prefer PERCEPTION (P). We can therefore conclude that designers

are strongly future oriented, concerned with possibilities
prefer working with others
are largely objective
have an open, questioning attitude

3.5.4 Designers

Comparing typical designers with architects (cf. 3.4.4), they too are markedly INTUITION (N) but not so INTUITION as fine artists (cf. 3.4.5). The intuitive, future oriented, seeking of possibilities is a shared characteristic among these creative groups. Designers are more EXTRAVERSION, and may prefer playing their part in teamwork.

A high percentage of designers prefer PERCEPTION: they prefer to keep their options open. INTUITION with PERCEPTION (NP) account for over half of the sample.

A large number cluster in one single type (ENTP). It is notable that the ENTP result for designers is the reverse of that for fine artists. This may be explained by the depth of FEELING (F) demonstrated by fine artists (ie. values and person-centred) versus the THINKING (T) of the designers showing a more analytical approach. Overall, this sample is broadly in agreement with the expected directions for design, design-related, and other professions.

3.5.5 Anecdotal evidence

Following assessment for type, I was able to discuss informally individual results with some of the students, and was struck by the students' acceptance of their type descriptions[23]. Even where an individual's assessment ran counter to the majority of the group, students were able to accept and justify the result. For example, a student preferring SENSING • THINKING said she felt uncomfortable with open-ended projects, preferring instead those projects with tightly constrained functional requirements. Or the ESTJ who thought his type description accurate, and when it was suggested to him that his indicated type may be more typical of business and engineering, responded that he intended to go into the management of his family's engineering company. Or the young man who was strongly EXTRAVERSION: asked if he had a full social life, he replied "yeah — every night!". There were many other examples...

3.5.6 Other design courses

Design courses vary considerably in approach. For example, some are art-based and have an approach which fosters innovation, whereas others take a stronger commercial line. Some have a high engineering content, whereas others are rooted in craft work. One type of design course which is theoretically positioned somewhere between design and business studies is the relatively new study of design with marketing. It was conjectured that there will be differences between the motivations of students applying for different subject specialisms.

Design/marketing[24] is different to most design courses in that half the study requirement is in marketing, a subject more usually taught within business or management studies. My experience of teaching on this type of course fostered a view that the students cope with more in-depth quantitative analysis than is usual in design studies and conjectured that, as a group, these students might demonstrate preferences situated somewhere between design and business.

23 Some descriptions of the preferences of the 16 psychological types were available to students after the questionnaire had been completed.

24 At the Institute of Design, University of Teesside.

Part of the UK designer sample reported above comprised a first year undergraduate cohort specialising in design/marketing. A total of 10 design/marketing students were assessed. It must be stressed that this is a **very small sample** and results must be treated with great caution. They are reported here as an indication only, and are subject to verification by a larger sample.

ESTJ 10 (1)	ISTP 0 (0)	ENTJ 20 (2)	INTP 0 (0)
ISTJ 0 (0)	ESTP 10 (1)	INTJ 10 (1)	ENTP 10 (1)
ISFJ 0 (0)	ESFP 20 (2)	INFJ 0 (0)	ENFP 10 (1)
ESFJ 0 (0)	ISFP 10 (1)	ENFJ 0 (0)	INFP 0 (0)

Figure 3.24: Design marketing students (n=10)

It will be noted that

- there are equal numbers of SENSING types and INTUITION types (N)
- this is combined with more THINKING (T) than FEELING (F)
- 80% prefer EXTRAVERSION (E)
- 60% prefer PERCEPTION (P)

If these data were from a larger study and more reliable, we might be able to say that the sample is in line with a typical designer sample in respect of EXTRAVERSION (E), THINKING (T), and PERCEPTION (P). However it moves towards business managers in respect of SENSING (S) This seems consistent with theory. We *might* therefore conclude that design marketing students

prefer working with others
are more objective and factual
largely have an open, questioning attitude

3.6 Conclusion

In the context of this investigation, data arising from a personality indicator have been demonstrated relating to occupations which are both similar and dissimilar to design. A total of 16 psychological types can be identified. The results of a survey of UK design students have been reported and are broadly in agreement with other data for cognate professionals. An outline description is given of designers' root preferences arising from their personalities, and this reinforces and develops the general descriptors for designers stated in the last chapter.

Theoretically, in any given occupation all 16 types may be found, but some types are more attracted to certain occupations than other types. This self selection is thought to be indicative of the degree of consonance between individuals and the professions they choose. Generally, the clustering of design students is quite different to some other professionals with whom they might be expected to interact in a teaching situation eg. business, computing, and engineering.

The survey of design students shows them to be high on INTUITION, and they prefer the PERCEPTION attitude. This leads them to be imaginative, future focused, open-ended and curious about their world[25]. Their profile is quite different to the sample population, particularly in respect of INTUITION: 79% of designers against 24% of population. They also score high on PERCEPTION attitude: 69% of designers against 34% in a general population. Designers share some characteristics with cognate professionals such as architects and artists. They all score high on INTUITION, architects about the same, but fine artists rather higher. In common with architects, designers' other major process is THINKING. In this respect they differ from the artists who markedly prefer a FEELING process. We may therefore conclude that designers and architects, perhaps more connected with the world of products and technology, have use of the analytical and logical processes which the THINKING process brings. Artists, on the other hand, tap the resources of FEELING in their

25 From my experience of teaching similar students, the strong PERCEPTION attitude seems to be borne out by the often encountered difficulty of getting design students to stop ideating, or otherwise endlessly collecting data, and to make decisions (a JUDGMENT attitude) about how to proceed to a designed solution.

quest for self, and are happier with more value-laden subjectivity. Both artists and architects have a bias toward INTROVERSION which brings more independence, concentration, and acceptance of working alone. The sample of design students, on the other hand, are mainly EXTRAVERSION and may prefer more action and teamwork.

The design students' largest grouping is ENTP. Of this type, Myers has written

> "For example, those ENTs who find intuition more interesting than thinking will naturally give intuition the right of way and subordinate thinking to it. Their intuition acquires an unquestioned personal validity that no other process can approach. They will enjoy, use, and trust it most. Their lives will be so shaped as to give maximum freedom for the pursuit of intuitive goals. Because intuition is a perceptive process, these ENTs will deal with the world in the perceptive attitude, which makes them ENTPs [...] They will consult their judgment, their thinking, only when it does not conflict with their intuition"

Some other professionals also exhibit a strong, but distinctly different, type profile. In line with theory, the more factual business managers overwhelmingly use SENSING with THINKING, and three quarters of them prefer a JUDGMENT attitude. This particular mix of attributes (STJ) is sometimes referred to as *tough minded.* They are very different to the designers. The mechanical engineers are similar to managers in being practical. The computer professionals strongly prefer a THINKING process which makes them very analytical. Although these characteristics can be said to be typical of an occupational group (or at least the majority of an occupational group) it has to be remembered that, with few exceptions, occupational groups have representatives in most types — to a lesser or greater extent. This is true for all the groups. There is not one style appropriate for the *whole* of an occupational group — there may be several styles. However, a set of styles suitable for one group may be quite inappropriate for another group.

The aim of this chapter has been to demonstrate a reliable method for describing designer personality. The data presented here are coherent across the occupational groups, and comparisons of designers with non-design professionals show marked differences in expected directions consistent with theory. Designers can be distinguished from a general population and from other professionals with whom they might be expected to come into contact in a teaching situation.

Chapter 4

Styles of CAI

4 Styles of CAI

4.1 Introduction

In chapters 2 & 3 we have seen that individuals exhibit differences in certain aspects of cognition and personality. We have also seen that designers can be identified with certain types of personality. But do CAI systems also have (or are they capable of) differences in styles? Such styles would be manifest in ways in which computers deliver pedagogic materials and interact with learners.

In the dialogues between humans and computers differences of style are well documented. For example, Downton (1991) identifies human-computer dialogues ranging from simple command-line instruction through to more powerful *direct manipulation*[1] as seen in modern personal computer operating systems. Differences of interaction style are therefore apparent at the level of operating systems. In the use of hypermedia, styles may also be evident in the restrictions imposed upon authors by the type of authoring tool used, particularly if predetermined templates are used. Similarly, different kinds of media represented by hypermedia may have a different impact upon various users. The use by authors of various pedagogical models may also impart certain characteristic flavours to CAI. It may be observed that, compared to humans, computers have different *abilities*. Figure 4.1 shows some of the relative strengths and weaknesses of each.

Human abilities	Computer abilities
estimation	accurate calculation
intuition	logical deduction
creativity	repetitive activity
adaptation	consistency
abnormal/exceptional processing	routine processing
associative memory	data storage and retrieval
world knowledge	domain knowledge

Figure 4.1: Relative abilities of humans and computers (adapted from Downton, 1991)

1 Direct manipulation allows users to feel that they are directly controlling the on-screen objects represented by the computer, eg. dragging a document icon to a folder icon. The icons are graphic representations of real world objects.

In reviewing the effects of cognitive style on designers' teaching and learning with computers, Cross (1985) proposed that what may be termed the *cognitive abilities* of computers (as influenced by both hardware and software) are restricted to certain very limited aspects of

- *propositional* style — or convergent, serial/sequential style

Conversely, we have already seen that designers cognitive abilities are more

- *appositional* — or divergent, holistic

The view that the operation of computers is inherently propositional is broadly supported by Thimbleby (1990) who shows that computer programming is analytical and decisive in approach. At the level of software applications, most interactive systems are written in imperative languages, therefore this style of software design follows naturally. He also suggests that, as computer systems developers are generally of an analytical type themselves (ie. propositional), the system interfaces which they develop are formed in the same style (cf. 3.4.10 for the personality type of computer specialists). This propositional quality of computer systems may be reflected in the structures of hypermedia, and may be particularly contrary to the natural preferences of designers.

4.1.1 Aims

This chapter provides some background to the discussion on styles of CAI by firstly outlining the history of the main influential concepts and developments in hypermedia before moving on to more specific aspects. The aims of this chapter are to set out the territory by

- providing a historical introduction to the key developments in hypermedia technologies
- discussing some general aspects of human-computer interaction
- discussing some related aspects of media types
- setting out a simple taxonomy of CAI styles

4.2 Historical review

Many of the concepts leading to the development of hypermedia can be traced back to the beginnings of writing and beyond. Ideas for mechanising the retrieval of information and for connecting the world's literature first surfaced during the 1930s and 1940s. In a lecture given in 1936 the visionary Wells (1938) described his idea of a *World Encyclopaedia* which would

> "...spread like a nervous network [...] knitting all the intellectual workers of the world through a common interest and a common medium of expression into a more and more conscious co-operating unity."

4.2.1 Memex

The starting point most often cited is the article *As we may think* by Bush (1945). Since the 1930s Bush had an interest in the mechanisation of documentation with particular reference to technical information. He saw with great clarity the problems associated with ever increasing volumes of information

> "The summation of human experience is being expanded at a prodigious rate, and the means we use for threading through the consequent maze to the momentary important item is the same as was used in the days of square-rigged ships."

His view was that, at the time, methods for transmitting and reviewing results of research were outdated and becoming inadequate. He went on to conceptualise a new machine. He called this the *Memex*, and it was a device

> "in which an individual stores his books, records and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility."

But the conceptual design of the Memex was more than just a mechanized file and private library. The essential feature of his machine was the linking together of pieces of information, which he felt was modelled on the way brains work

> "It operates by association. With one item in its grasp, it snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain."

Bush therefore articulated the notion of *associative indexing* whereby any item can be made to automatically select another. He thought that new forms of encyclopaedia would appear, with associative trails running through them. At the time, Bush had no technology which would instantiate his design. The Memex required the development of the computer.

4.2.2 Augment

Bush's ideas came to dominate Engelbart's thinking at the Stanford Research Institute in the 1950s and 1960s, who went on to lead many of the fundamental concepts which we now take for granted in personal computing (Engelbart, 1963). Though perhaps best known for the development of the first *mouse* pointing device, he pursued his vision of hypertext based on augmenting or amplifying human intellect. This led to *Augment* [2] which allowed users to create documents based on connected concepts, and to collaborate with others on the joint development of documents. Demonstrated in public for the first time in December 1968, Augment was designed as an environment to serve the working needs of researchers, containing all the required documents, memos, notes, and reports. It also supported planning, debugging and communication. It was primarily hierarchical but allowed reference links to be established between levels and between files. It supported more than one person working jointly on a document, and was one of the the earliest attempts to provide an environment in which computer-supported collaborative work could take place. Augment produced many features which are now standard in personal computing, including text processing, electronic mail, multi-document screen displays and user interaction.

4.2.3 Xanadu

The term *hypertext* was coined by Nelson (1974) and first used in the early 1960s. He defined hypertext as follows

> "By 'hypertext' I mean non-sequential writing. Ordinary writing is sequential for two reasons. First, it grew out of speech [which is] sequential, and second, because books are not convenient to read except in a sequence. But the structures of ideas are not sequential. They tie together every which way. And when we write we are always trying to tie things together in non-sequential ways" (Nelson, 1974).

Over the years, his vision has persisted (Nelson, 1981, 1988). His intention is simple: he aims to connect all the world's literature. His *Xanadu* project[3] is concerned with the construction of a hypertext server to create a *docuverse*, a structure in which documents containing the entire literature of the world are linked

2 Augment was originally named NLS (oN Line System) at its introduction, but was renamed Augment when it was released commercially by McDonnell-Douglas.

3 Named after the site of Kubla Khan's pleasure dome in the Coleridge poem

by the employment of *transclusions*[4]. The project has yet to be fully realised commercially, though Nelson has mapped out much of the theoretical territory subsequently explored by hypertext developers.

4.2.4 Hypertext

Simply stated, hypertext consists of *nodes* of information and *associative links* between them. Any text which references another can be seen as two nodes of information with the reference forming the link. This interconnectedness or *intertwingularity*[5] of information has long been appreciated, and it is this which is at the heart of hypertext. It has been shown by McKnight, Dillon & Richardson, (1991) that as such, associative linking is not new. There is evidence of such links going back to well before the advent of printed books. However, these researchers point to several physical constraints to the presentation of textual information on paper. The layout of texts — and therefore the mode of reading them — is essentially *linear* (ie. it is read in a sequential manner) and this leaves the reader with the task of physically finding cross-references, volumes or sections. On the other hand hypertext systems allow the reader to access references quickly and to see associated material in a non-linear fashion. What sets hypertext apart from the most intertwingled paper documents is the ability of the computer to support these associative links in an effortless and seamless manner. It is therefore the advent of the computer that has enabled the concept to come to fruition.

Information nodes need not be restricted to text. The notion of a node is very general and there are no rules for what gets linked to what. Similarly, links may be fixed by the author, may be formed by the user, or may be semantic links shaped on the fly by the user's selections of keywords or other information.

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4 All literature is to be linked employing *transclusions*. A document is built up of original (or native) fragments, and fragments which are inclusions from other documents in which they are themselves native. The term 'transclusion', implies the transfer and inclusion of one document into another. Transclusion is however virtual, with each document containing links to the original document rather than having copies. In a Xanadu structured docuverse nothing need be written twice.

5 One of Nelson's many new words. He has stated "Intertwingularity is not generally acknowledged — people keep pretending they can make things hierarchical, categorizable and sequential when they can't. Everything is deeply intertwingled." (Nelson, 1974)

4.2.5 Intermedia

One early project from the late 1960s (Yankelovitch, Hann, Meyrowitz & Drucker, 1988) developed into *Intermedia* at Brown University, USA. This is a hypermedia system comprising tools for text and graphics processing, time line editing, scanned image viewing, and 3D applications suitable for a variety of purposes. It introduced the notion of *webs* or sub-assemblies of the total hypertext network. When a web is invoked, only the links between nodes relevant to that web are displayed, thus allowing different teachers to construct a variety of *trails* through the domain (using common materials) to which students can add their own links and annotations. It is one of the most widely referenced projects, and has been used to teach several courses in subjects such as biology and English literature.

4.2.6 Microcosm

At the campus level, *Microcosm* is a hypertext system developed at Southampton University (Fountain, Hall, Heath & Davies, 1991) and launched as a commercial product in 1994. Microcosm is an open architecture hypertext system which facilitates linking materials across a network such as a university campus. It may prove to have significance for the distribution of hypermedia teaching materials, particularly within academic *hyperspace*[6]. Microcosm allows link information to be separated out instead of being embedded in a document, the philosophy being that hypermedia links are in themselves valuable knowledge. If separated, the links can be generic. Instead of being applied only to one document, they may be used in a whole class of documents.

4.2.7 WWW

At a more global level, the latest development of the hypertext concept is instantiated in the *World Wide Web* (WWW). This exists as a software protocol which provides inter-document links across *Cyberspace*[7] (Hughes, 1994). By

6 Hyperspace: the domain of information in hypertexts (Conklin, 1987)

7 Cyberspace: the domain of information across the Internet, first coined by Gibson (1986) in the science fiction novel *Neuromancer*.

clicking on a *hot spot* [8] embedded within a document, the user is automatically linked to another part of the same document, or to a location in a remote document anywhere on the Internet. So far as the document author is concerned the core of the system is a specialised hypertext markup language (HTML) by which the author embeds instructional codes into the text. Information navigation is via a web *browser* which provides a graphical point and click interface. The WWW has potential for storing and communicating the full range of hypermedia, especially as network communication speeds increase.

4.2.8 Programmed learning

From the 1960s and 1970s several programmed learning applications were developed, with authoring systems such as *PLATO* and *TICCIT* [9]. This type of self-learning programme is strongly related to rote learning, and has met with varying success. At first, the style of such systems was command-line interaction using text only, but later included graphical interfaces. O'Shea & Self (1983) have discussed how these new applications developed from a tradition of linear teaching methods characterised by systematic presentation, reinforcement, and self-pacing. Later, branching programmes (which provided users with constrained choice) introduced corrective feedback. What are termed *drill and practice* systems introduced levels of task difficulty, and these have been successful in certain areas of training, such as with the military[10]. In a review of programmed learning (Eberts & Brock, 1988) it was shown that, at best, improvement in student achievement was very low when compared with traditional teacher-based techniques. They go on to state that this type of training is

> "best applied where the content to be learned is factual, with specific goals and objectives."

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8 Hot spot: an area of the screen which may be selected (eg. by a mouse click) from which a programmed action takes place. A pushbutton metaphor is often used.

9 PLATO: Programmed Logic for Automatic Teaching Operation. TICCIT: Time-shared Interactive Computer Controlled Information Television.

10 For example, in teaching people to receive Morse code transmissions, a drill-and-practice computer based system was found to be an optimal solution. In this instance a predominately psychomotor skill is taught that requires plenty of practice to master. It has been claimed that the introduction of computer based methods has reduced a course dropout rate from 39% to under 10% over a four year period. Listserv discussion archived at EDTECH@msu.edu dated 2 May 1995; and personal communication.

but is less applicable where knowledge is not explicit. Similarly, in a report by the LTU[11] (1988) on UK providers and clients of computer based training, the market has been found to be primarily for training in procedural skills; teaching facts; form filling; training in IT applications (eg. word processing and spreadsheets); and sales training. Drill and practice programmes are seen as efficient for practising skills, but trainers showed little interest in giving their students a deeper, conceptual understanding. Programmed learning is therefore characterised as learning and practice of skills within a narrow domain, and is often discrete instruction not reliant on other learning materials.

4.2.9 Open & distance learning

More recently, quite different approaches to structured learning have been devised, often based on open learning[12] methods where the CAI is part of a larger course of instruction, often at sub degree or undergraduate level. Many of the TLTP packages are of this kind (see Donnelly, 1994 for several examples). In distance learning[13], the Open University, UK, has pioneered several approaches. One such example of design related distance instruction is CADPAC (Johnson, 1989). This was first introduced in 1987, aims to teach the fundamentals of computer-aided design, and is a significant part of a technology level 3 course. CADPAC comprises a suite of varied modules which are linked by a common menu structure, and is integrated as a home experiment kit supported by a comprehensive handbook. It includes a commercial CAD modeller.

4.2.10 Use of metaphor

Metaphor has a wide use in CAI and computer interfaces generally. This is often used to provide easily recognised real world images in order to tap into users' existing skills in, for example, the handling of documents or the reading of books.

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11 LTU: Learning Technologies Unit of the Employment Department, Sheffield, UK.

12 Open learning may be defined as the use of self-study packs by students who study these as part of a defined course of instruction, often with tutorial support, and sometimes as the self-study element of an otherwise conventional course of education. This usually centres on a host teaching establishment.

13 Distance learning may be defined as the use of study materials remote from tutorial support. If tutorial support is offered, this is often via telephone or correspondence. Students are geographically widely spread from the host teaching establishment.

Many interface elements which are now commonplace have their genesis in the *Dynabook* concept introduced by Kay in 1968. This book-like metaphor was theoretically conceived as a highly portable hypermedia system intended for use by schoolchildren. Also proposed was a kind of *paintbrush*, and the possibility of links to other Dynabooks and library resources via telephone lines. Although the concept has still to be fully implemented in the way it was intended, Kay went on to develop considerable spinoffs from the project. For example, the Dynabook's graphical interface influenced Xerox's Star workstation which in turn provided the inspiration for the introduction of the Apple Lisa and Macintosh computers in the early 1980s (Sculley & Byrne, 1987).

A different kind of metaphor was employed in *Guide* (Brown, 1987). This was one of the earliest microcomputer implementations of hypermedia. Begun in the early 1980s, Guide is loosely based on a paper document metaphor with the user perceiving the text as a long, linear document *folded* at some points to hide underlying information, and thus exposing the headers. The document may be traversed by clicking on these headers whereupon the folded text is presented by *opening out.* Nesting may be many layers deep, and any contiguous text may be treated as a hot spot for linking with other information. A read-only version of Guide has been used to distribute books (McAleese, 1989; Nelson, 1981).

NoteCards (Halasz, Moran & Trigg, 1987) was designed as an information analyst's support tool and, as its name suggests, it employed another kind of metaphor, the well known index card. Although it was made available commercially, its market penetration has been minimal but, like so much of the work at Xerox PARC, its influence has been considerable. Perhaps this influence is most obvious as the model for Apple Computer's *HyperCard* (Goodman, 1993). HyperCard is credited with popularising the hypermedia concept. It is widely used, particularly in schools in the USA.

4.2.11 Databases

Another way in which information can be delivered is in the form of hypermedia databases. These are not necessarily intended to teach anything (nor do they expressly have a structure for so doing) but they are intended to provide information on demand. These systems may be perceived as an electronic replacement for catalogues, and are sometimes known as *kiosks* when implemented in a public space on a computer with a simple interface such as a touch screen. One notable such development is *Hyperties* (Shneiderman, 1987). This system is centred on the model of a database of nodes and links, and has been used extensively in museum applications for public access. An extension of these ideas was *StrathTutor*, a frame-based learning-by-browsing tutoring system (Kibby and Mayes, 1989). StrathTutor differs from conventional hypertexts in that there are no explicit links between frames. Instead, the author grades each frame with up to 60 attributes, and links are then formed at run-time using pattern matching heuristics according to the type of interaction which the learner initiates. A further claimed advantage of the lack of fixed links is that frame editing, and therefore subsequent necessary maintenance, is made easier.

4.3 Human-computer interaction

The literature on human-computer interaction (HCI) varies considerably in subject matter and in depth of treatment. It has a wide spread across electronic engineering and computer science; psychology; ergonomics; linguistics; and graphic design and typography. In a detailed introduction to engineering methodologies for HCI, Downton (1991) states

> "effective communication with users seems to present an intractable and intangible problem whose solution is clouded in the indeterminacy of human behaviour. The limited nature of experimental evidence and primitive level of formal theories in the human sciences contrast starkly with well-proven, elegant and concise formal methods which are widespread in engineering and computer science"

Similarly, in a review of hypermedia, Schroeder (1991) mentions several design issues yet to be resolved. Among these issues, hypermedia systems can be both confusing and disorienting to use, and interfaces are not *friendly* enough for many users. Additionally, some systems may be sacrificing depth for breadth. Although

there is a recognition by several authorities of learning style needs by individual learners, there is little evidence of learning styles or personality factors being seriously considered as an integral aspect of human-computer interfaces.

4.3.1 Channels

Human-computer interaction may be thought of as three main channels of communication. These are described by Baecker & Buxton (1987) as the *visual*, *audile*, and *haptic*[14] channels, and are ranked by Downton (1991) in that order of importance.

4.3.2 Visual channel

Much of a typical user's interaction with a computer is screen-based and is therefore dependent upon visual information presented in a textual or graphical form. Screen based interaction is probably the most widely researched area, and there is an extensive literature[15]. Although Lazzaro (1991) has warned that good graphic design does not always indicate good *information bearing* design, Parker (1988) shows that screen layout is largely a graphic design problem addressable by similar principles as would be applied to communication design for print or signage. However in reading, screen displays differ from paper based text in some important respects, particularly reading speed which is slower on screen (Aspillaga, 1991); slower retrieval of information (Marchionini & Shneiderman, 1988); and the need to make reading easier by breaking text into discrete sections (Faiola & DeBloois, 1988).

4.3.3 Audio channel

Potentially there is a wide variety of audio-based interactions. For instructing the computer, the subject covers speech recognition, speech synthesis, and speaker recognition, though these technologies are at an early stage. As a medium for

14 Derived from a Greek word meaning touch or contact

15 There is an especially wide literature on typography. It is probable that more research has been conducted in typography and legibility than any other area of graphic design, though most research applies to print. There is a comprehensive bibliography in Apple (1992). Also see Ellis et al. (1991) for a discussion of advanced research in pictorial communication.

information delivery, sound can play an important role particularly with help messages, supplementary data, warnings and mood-setting music. Baecker & Buxton (1987) have shown how sound in video games has considerable potential to express high level messages: if the sound is removed, players' scores suffer.

4.3.4 Haptic channel

Baecker & Buxton (1987) highlight the haptic channel as not yet being used to its full potential in HCI. The haptic mode of interaction embraces all the touching, tactile, and kinesthetic aspects of humans interacting with computers. Typical haptic input devices are mouse, keyboard, trackball, joystick, and digitising tablet. In general, input is mainly related to hands[16]. Although in one sense every input device provides output through tactile or kinesthetic feedback to the user, haptic output devices are quite rare, for example output in braille. There are also implications for direct manipulation when drawing/writing direct to screen with hand gestures, as these gestural modes may become more important with handwriting recognition systems due to the translation from mouse to screen not allowing for the same finesse as using a pen. Interfaces have been considered which adapt to the user's hand and finger characteristics. Such an interface, based on an anatomical model of the hand, has been reported by Riecken (1992). Although properly a part of *virtual reality* technology, the *dataglove*[17] may find use with other kinds of gestural input eg. computer based teaching of signing to the deaf.

4.3.5 Navigation

Among the most difficult problems affecting HCI are those surrounding the *navigation* of hyperspace. In his comprehensive review of hypertext, Conklin (1987) identified some key research issues as

- *disorientation* or getting lost in hyperspace
- *cognitive overhead* or the additional mental overhead associated with keeping track of hypertext links. This is especially difficult with large scale exploratory

16 Also suck/blow devices, tongue control, eye tracking, etc., especially for computer users who have physical disabilities.

17 A wired glove which provides positional input to the computer for menu selection etc.

hypertext systems which are typically used by browsing.

At a more localised level, navigation difficulties may also include

- finding the correct information unit *granularity* [18] for particular task domains and users
- presenting interfaces with better selection and feedback mechanisms
- striking a balance between analytical and browsing search strategies
- stepping back through material already experienced
- getting back to a menu

Time based media (eg. video and sound) are sequential. For the user to have some control, this requires sequences to be packaged into chunks, with pacing controlled by the student (Muller, Farrell, Cebulka & Smith, 1992). Basic controls may include

- being able to interrupt a time-based sequence; pausing
- skipping over segments
- repeating a sequence

Davis, Hall & Hutchings (1994) have also pointed to differences between analogue video (ie. videodisk) and digital video. Analogue video is frame based and therefore can be readily accessed at the frame level. With digital video this is not applicable so it becomes more important to chunk the material meaningfully both for learning and for random access.

One main difference between traditional texts and hypermedia is that the structure of hypermedia is not apparent by looking at it (Davis, Hall & Hutchings, 1994). Typically, users can get lost, may find it difficult to gain an overview of the subject or, even if they know that target information is present, may have difficulty locating it. A form of hierarchal indexing may be employed. For example, Nolthuis (1992) has postulated a route button linked to a map which represents a

18 Granularity: chunking of information. This might apply to information content, or to the structures which support information.

graphical index of the program: from the index it is possible to launch to other areas. However, where maps are provided, often in a spatial metaphor Laurel, Oren & Don (1992) have shown that these can become extremely complex and difficult to understand.

4.3.6 Electronic books

Some positional information can also be imparted by relying on a structure of chapters, headings, sub-headings etc. similar to the organisation of paper texts. This has led some researchers to consider the emulation of books on screen. McKnight, Dillon & Richardson (1991) have shown that literate societies have, over several centuries, developed special skills in both the reading of texts and the handling of them. The physical size of a textbook is obvious, and so is the reader's position in the text. No such visual cues are obvious in hypermedia unless they are explicitly designed. Barker and Manji (1988) and Barker (1991) have attempted to map the structure of physical books as *electronic books* and then provide detailed recommendations. As well as conventional book features such as chapters and page layouts, book emulators may also simulate page-turning. Perhaps the best known example is the *Book Emulator* (Benest, 1990) where the physical appearance of a book is represented on screen. Benest rejects the notion that a new medium such as hypermedia demands a totally new interface approach. Page structures have also been studied including the special interface problems associated with non-linear hypermedia books (Richards, Barker, Giller, Lamont & Manji, 1991). Others such as Nievergelt & Weydert (1987) have expanded the interface, especially with picture books, often for an instructional rather than just an informational purpose.

4.3.7 Media

We have seen from chapter 2 that individuals have preferences for certain kinds of images. Might various media be seen in different ways, and be more acceptable to some people than to others? The diverse media which constitute hypermedia have varying capacities to deliver information, and are perceived by individuals quite

differently in respect of the authority which they convey (Laurel, Oren & Don 1992).

4.3.8 Computer as media

Receiving information through a computer is likely to be a different experience than receiving the same kind of information through other means. For example, the reading of texts is significantly different on screen than on paper, although the computer offers, through hypertext, considerable potential for experiences not available by paper-based delivery. We can also see that human-to-human conversation is modified where these dialogues are facilitated through the medium of computers. Fuller (1994), in a carefully detailed study, showed such distortions of communication. A group of subjects who regularly communicated with each other electronically (by email) were tested for personality styles. They were then asked to assess the personality style of the other person with whom they regularly communicated. The electronic group was then compared with another group of persons who did not communicate electronically. This control group utilised face-to-face communications instead. The electronic group consistently perceived the person with whom they communicated to be more *analytical*[19] than did those from the non electronic group. This is verification of the kind of breakdown in human-computer-human communication which was described by Winograd & Flores (1986) as the invention of a network of understanding that is incorrect and private, that cannot be shared, and that inhibits communication. In this respect, computers may be seen to impart a style of communication which is analytical.

4.3.9 Media credibility

The primary media with which we are concerned in hypermedia are

- text (as both static text and hypertext)
- motion video; still video
- drawings
- animation (drawings or pictures that move)
- sound

19 This was significant at the level of $p<.003$

In their ability to represent information, media have different dimensions. For example, Laurel, Oren & Don (1992) have shown that users generally believe that video inherently has less content than text, therefore the information contained in video is less credible. Textbooks are therefore perceived as a more reliable source of *truthful* or *academic* information than video. More specifically, Lazzaro (1991) has classified text as being good for precise information, especially numeric data; abstract notions; and logical deductions. Laurillard (1993) has pointed to television (a form of video which is non controllable) as a powerful medium for conveying ideas through *association* of concepts, effects such as montage, footage on locations etc. Television's persuasive power is considerable but it is perceived as being poor in information. Additionally the lack of control over the rate of delivery of television means that the viewer can be swamped with information. In this respect texts are more credible, and carry more authority. These differences may be summarised as follows

- text (truthful and academic; authoritative; precise information; logical deductions)
- video (ideas / association of concepts; site locations; but less authoritative and precise)

4.4 Control

The interface between human users and computer systems is a mutual boundary which accommodates elements of both user and system. While the computer system is largely embedded in hardware, operating systems and application software, the user brings individual attitudes, skills and prior knowledge, and these form a complementary but intrinsic part of HCI. From the user's perspective some CAI systems appear to give the user a large amount of choice over their learning experience, whereas other systems provide little choice. McAleese (1990) has suggested that by the judicious use of hypertext links and *appropriate structures* learners could take more initiative for their own learning. Hypermedia which offers a range of choices is potentially a powerful aid in placing initiative more in

the hands of learners, but it is unclear what kind of structures might be *appropriate*. Jonassen (1988) has stated that cognitive psychology provides rich conceptualisations to guide access to hypermedia. Paths may be related to

> "individual differences, such as field articulation, serialist/holist learning style, etc."

Jonassen has observed that

> "Preferential matching of learners to instructional treatments based upon their individual knowledge structures has been the theoretical goal of [authors] of intelligent systems. Hypertext provides that possibility."

However, little practical evidence is offered which is suitable for the authoring of hypermedia, particularly in respect of matching hypermedia structures to individuals' learning styles.

Davis, Hall & Hutchings (1994) question whether many applications are no more than electronic page turning, believing that hypermedia is low on interactivity compared to other media[20]. Various *levels* of interactivity are sometimes mentioned in the literature though these relate mainly to videodisc which is assumed to be the central medium for instructional delivery. Among the many definitions of *interactivity*, Laurillard (1993) defines it as

> "involving intrinsic feedback on what the student does - the information in the system should change as a result of their action"

However, this view is not widely supported. More typical is a definition by Schwier & Misanchuk (1993) who state that CAI

> "includes a variety of integrated sources in the instruction with a computer at the heart of the system. The program is intentionally designed in segments, and *viewer responses to structured opportunities* (eg. menus, problems, simulated crises, questions, virtual environments) *influence the sequence, size, content, and shape of the program*" (my italics)

This definition is closest to the CAI styles reported below.

4.4.1 Balance of control

In the interaction between human users and computers there is a balance of control located somewhere between the user and the computer system. This balance has

20 The term *interpassive* is becoming widely (but cynically) used to describe simplistic programmes where, by allowing the user to point and click at information, the author provides an illusion of interaction. For example, see the discussion on MMEDIA-L 27 April 1995 archived at listserv@itesmvf1.earn

been termed *initiative* by Downton (1991) who defines it as the most fundamental property of human-computer dialogues. These dialogues are either

- *computer initiated* or
- *user initiated*

4.4.2 Initiative

In computer initiated dialogues the user responds to explicit prompts from the computer to input commands. Typically, the user will be presented with a series of options from which to make a selection. The key characteristic is that the user's choice is constrained by a closed set of options presented by the computer. In the context of CAI, this equates to a restricted style of interaction where the computer constrains the user to predetermined responses and pathways. The extent of system initiative may be influenced by

- *authoring tools* (these include elements of both computer operating systems and other constraints imposed by the predetermined structures of hypermedia authoring packages)
- *authors* of CAI (who select and organise information, and present it in particular ways which are intended to impart knowledge to learners)

System initiative can therefore be seen as the extent to which any hypermedia authoring software imposes structure on content or delivery, as well as constraints imposed (intentionally or unintentionally) by the author of CAI. At its most basic level, system initiative may consist of no more than playback of an animation sequence which the user cannot interrupt. At higher levels there may be systems which modify interaction based on the system's analysis of user behaviour.

User initiated dialogues, in contrast, are more open ended in nature. They typically embrace all modes where the user is expected to know the structure of the system, or prefer to find their own way around. In the context of CAI, this equates to a

more freeform style of interaction where the computer facilitates a user's exploration of the domain.

Following from these states we can also define *variable initiative* dialogues where the initiative is taken by either user or system under varying circumstances. These circumstances may be determined by either the user's choice or by the computer operating according to rules.

4.4.3 Instruction & databases

In discussing initiative, it will be useful to differentiate between two types of educational materials

- *instructional systems* (which comprise knowledge, and are structured with a teaching purpose)
- *information resources* (which comprise information organised in the form of databases, but which have no explicit teaching structure)

Both may form part of a CAI system, the one for imparting knowledge assembled by an author in a manner consonant with principles of teaching, the other for retrieving information in support of active teaching. Knowledge may therefore be seen as information formed and delivered for an instructional purpose, whereas information comprises data which have to be found and assimilated. Laurillard (1993) argues that merely linking information by means of hypertext systems does not provide an educational medium. For example, knowledge is information already transformed and in textbooks is arranged within a structured line of argument. Reducing texts to linked information undermines the intended argument. It therefore seems unlikely that hypermedia is of itself sufficient to support structured learning, at least in the browse and retrieve information model which has so far been predominant.

In order to establish a language for discussing styles of CAI in relation to designers' learning styles, a simple taxonomy of styles of CAI will now be developed from this division of systems for *instruction* and supporting resources for *information*.

4.5 Instructional systems

Instructional systems may be classified into two broad types, depending upon their structure, ranging from

- *linear* or highly constrained (with initiative predominantly taken by the computer system)
- *exploratory* (with initiative predominantly taken by the user)

In linear systems what the learner is to learn is highly prescribed. The instructional content and boundaries are decided by the author. Access to the content is rigidly structured. The learner's role is to receive instruction and to gain facility with the content. Exploratory systems, on the other hand, shift the initiative to the user. Learning is not so structured. The learner is permitted to influence what is learned, how it is learned, and the order in which it is learned.

The following terms will be used to describe the structures which support these modes of learning

Node: a node is defined as a point of information. This might simply be information, or could be data organised in the form of a lesson segment comprising any media.

Figure 4.2: Node

Link: a link is defined as a pathway between nodes. Links may be chosen by the user or by the system. A link is denoted by a line between nodes. Plain lines denote bidirectional links. For a unidirectional link, the direction of travel along the link is shown by an arrowhead.

Figure 4.3: Links, bidirectional and unidirectional

Tests: a test is defined as a node where a test of competence in the domain may be undertaken. Sometimes this may be optional, or it may be obligatory to pass the test before moving on.

Figure 4.4: Test

4.5.1 Linear instructional systems

Linear systems are characterised by being unidirectional and sequential. That is, the learner is obliged to step through the domain sequentially, exactly in the order intended by the hypermedia author, from one node to the next. The learner gains facility with the content, often through drill and practice methods. There is no user choice apart from selecting when to go to the next node. There is no going back. Apart from user choice over the pace of delivery, linear systems are characterised by system initiative.

Figure 4.5: Linear system

Linear systems are associated with rote learning and the more traditional methods of CAI. Particularly with the delivery of text, structural style owes much to the classical linear model of **beginning** ➜ **middle**, and ➜ **end**, with each section having specific content. This applies at whole lesson (or book) level as well as at a more micro level, with the structure remaining essentially two dimensional. The system usually has an embedded teaching model which is narrow and which the user cannot modify.

As linearity moves more towards exploratory systems, a common enhancement to linear systems is the use of return loops. For example, the user may have sufficient control to be able to return to a previous node in order to eg. repeat a lesson or to replay a video clip.

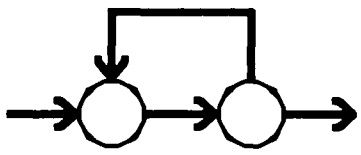

Figure 4.6: Simple return loop.

Sometimes, for instance where a test of competence is introduced, a loop is incorporated so that the learner may be referred to the previous node for remediation. This mode of teaching is widely used for training purposes and is appropriate when things have to be learned by rote.

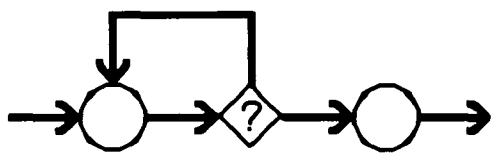

Figure 4.7: Simple return loop following test

Another enhancement to linear systems is branching to alternative nodes. Branching is a way of prescribing limited user choice in navigating through the domain. Branching may or may not be used with competence tests and return loops.

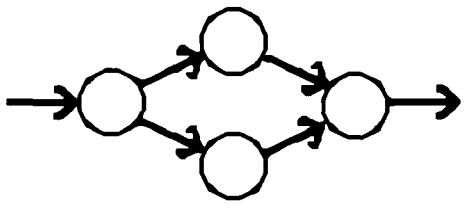

Figure 4.8: Linear branching system

Nolthuis (1992) has pointed to the importance of providing alternative routes through the domain to give the user control over the material covered, as well as control over the rate at which information is displayed, thereby encouraging *interactivity.* Branching allows some choice between predetermined alternatives.

4.5.2 Exploratory instructional systems

Exploratory instructional systems are based upon hypertext. These are quite

different to linear systems, and might be considered to be totally free in ways of access. However, instruction implies that the material, however exploratory it may be, should be experienced by the learner as a coherent, ordered lesson. Therefore this form of hypertext is guided. Learning is not so restricted as in linear systems and the user is empowered to explore more widely of the system (should they so choose) by accessing related information in near hyperspace. In this way learners are permitted to influence their learning experiences. The learner has certain links suggested (or imposed for clarity or pedagogic reasons) but can see and utilise other related links in order to flesh out the learning experience with their own selection of links to related materials. These relational links may be determined by the author.

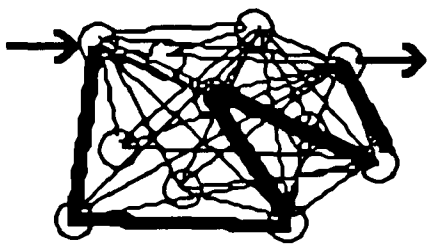

Figure 4.9: Exploratory instructional systems, based on guided hypertext.

One danger of hypertext based systems is that it is easy to create an amorphous network of nodes and links through which the learner may blunder in a disoriented fashion.

> "Every extra link is an additional burden on the user who has to determine whether or not to follow it. And if there are too many links leading to uninteresting places, then readers will quickly become disappointed and learn not to trust your judgment" (Neilsen, 1990)

It is the more freeform modes of hypertext which have promulgated many of the problems of navigation in knowledge domains. For example, *browsing*[21] carries more *cognitive overhead* (cf. 4.3.5) than more guided structures, and it is easier to get lost in hyperspace.

4.6 Information resources

Information resources comprise information used in support of guided learning, and are held in a database format suitable for search and retrieval. Woodhead (1990) has shown that there are similarities between hierarchical databases and

21 Browsing: a predominantly unstructured heuristic by which a user seeks information in hyperspace.

hypertext databases, but whereas the database model offers priority of logical form over contents, the hypertext model offers priority of content (objects) over form.

Information resources may be classified into two broad types, depending upon their structure

- *hierarchical* databases (with initiative predominantly taken by the computer system)
- *associational* or hypertext databases (with initiative predominantly taken by the user)

4.6.1 Hierarchical information resources

Databases are a traditional structure for information retrieval and browsing, and are usually associated with simple indexing arrangements. Structure is often based on hierarchical (or *tree*) structures. These are typically databases which present a constrained user choice at each node, often in the form of a menu selection. One item is selected, and a further node is encountered. In this respect hierarchical databases have similarities to branching linear systems, of which they are a specialised form. Appropriate means are provided to step back to previous nodes and, in more complex systems, various powerful retrieval techniques may be available such as indexing and query languages. A typical hierarchical structure is as follows

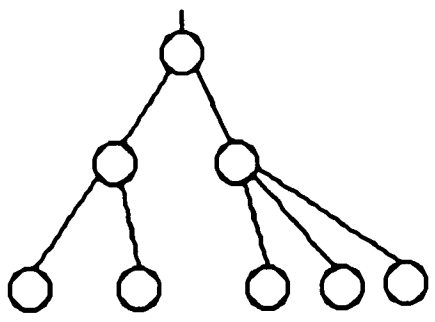

Figure 4.10: Hierarchical information resource

Although hypermedia can offer a database-like structure suitable for information retrieval, it is unlikely that by itself this approach will foster learning. O'Shea and Self (1983) have pointed to the majority of students being unable to set adequate

learning objectives for themselves and to study autonomously: undergraduate students are rarely capable of completely undirected reading. It might be expected that final year undergraduates and postgraduate students are more successful in undirected study.

4.6.2 Hypertext information systems

Resources based upon hypertext are associational. In this respect they are similar to hypertext based instructional systems, but lack the specific instructional guidance. Hypertext resources are intended for searching and retrieving specific information where nodes are linked by some relationship which may be defined by the user. Nodes may be linked by, for example, keywords or picture type. Links may be user directed by typing in keywords, or by pointing to related links embedded by the author. In this way information may not be *logically* classified, but be available to the user by semantic association. The user may also be able to save trails (or *threads*) through the domain for later viewing. This kind of structure is typical of hypertext systems

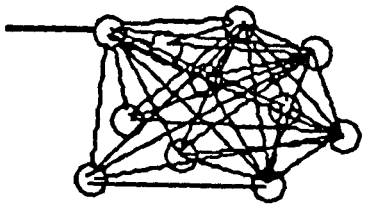

Figure 4.11: Hypertext information resource

Jonassen (1988) has shown that flexibility in search leads to complexity: as the number of options in large hypertext databases increases, so does the number of potential connections. Browsing is not an efficient way of learning, although Marchionini & Shneiderman (1988) have suggested that users often browse due to a long term commitment to, or interest in, a particular topic and may later benefit from extraneous information which is gleaned incidentally.

4.7 Conclusion

Hypermedia is a potentially powerful and persuasive medium for the delivery of educational materials. Among the opportunities offered by hypermedia are abilities to associate items of information; to unify disparate types of media within a common structure; and to allow comparison of information in ways not possible with conventional media. Of the channels of communication, the visual channel is well represented in research studies of screen design. Conversely, sound and the more tactile aspects of communication are less well investigated and less used.

In abilities and in human-computer dialogues we see emerging differences of style between humans and computers. Several major problems of HCI have been identified, including the disorientation which may be experienced when traversing large hypermedia databases. The use of metaphor has played a large part historically in the development of interfaces, and the promise of electronic books is that people's existing and deep skills in the handling of paper based texts are engaged. Much traditional CAI has been of a programmed learning kind, or is comprised of hypermedia databases with little or no instructional purpose.

Important differences are found between types of media. The computer itself affects communications by making them appear more analytical than would be the case if the people met face to face. Additionally, various kinds of media have different levels of suitability for conveying particular kinds of information. For example, a textbook has a ring of authority in conveying precise information, and may be perceived as academic in flavour. Television, on the other hand, carries less authority but is effective in associating concepts. The tone of media has to be carefully considered so that it has credibility for its target audience.

The extent of control of CAI is important. Initiative may be taken by either the user or the system. The focus of initiative is located between the human and the machine, and is implicated in notions of interactivity. Generally, hypermedia systems do not rate highly on interactivity. The user's experience of hypermedia

self-learning materials will be affected by limitations in the hypermedia such as constraints imposed by the particular authoring tools or by the author, whether these constraints are intended or not.

A simple taxonomy of CAI structures has been presented. Systems which comprise knowledge and which are intended for some instructional purpose (instructional systems) have been separated from those those systems which comprise information databases (information resources). These latter may support a learning process, but are not themselves structured for teaching purposes.

Two markedly different styles have been identified for each of these systems. For instructional systems, the styles are linear and exploratory. Linear instructional systems are characterised by a sequential, step-by-step style where the delivery of instruction is highly guided, and where initiative lies more with the computer. Exploratory instructional systems, on the other hand, are characterised by less guided instruction where learners can exercise more initiative to shape their learning experience.

The structures of information resources, termed hierarchical and associational, bear distinct similarities to linear and exploratory styles of instruction, but are shaped more towards searching for, and retrieval of, information.

The similarities between traditional programmed learning and forms of linear instruction are obvious. These are associated with drill and practice instruction and rote learning. Linear instruction also seems to match the propositional style thought to be natural to computers and software (cf. 4.1). Conversely, designers' cognitive styles seem to be aligned with a more appositional style.

Chapter 5

CAI using styles

5 CAI using styles

5.1 Introduction

Previous chapters have demonstrated that people exhibit natural ways in which they view their world and that they have preferences for the ways in which they receive information. Designers have been shown to have certain personality styles markedly different to a general population, and different to other professionals with whom they would be expected to come into contact in an educational or commercial setting. Additionally, CAI has been shown to be capable of certain styles of delivery. But how can CAI be authored in appropriate styles to suit students of design and other learners?

5.1.1 Aims

Thus far the MBTI has been used as a way of classifying people, both as individuals and as groups such as those those with certain occupations. Learning styles can be related to these 16 psychological types. This chapter revisits the MBTI scales with the intention of defining learning styles and mapping these to appropriate treatments which will form the basis of a CAI model adaptive to learners' preferences. Additionally, there are some pointers to preferences for possible instructional models. Having established the groundwork for an adaptive CAI system, one example of a practical method for implementation is suggested.

The aims of this chapter are therefore to

- distil the broad characteristics of psychological types which underpin learning preferences into specifications for an adaptive CAI model

- explain the workings of this new CAI model and its advantages

- propose one way in which to operationalise the new CAI model

5.2 Mapping learning styles

The literature on learning preferences related to MBTI psychological types is based on empirical observations of these types in learning situations. Furthermore, although particular learning styles are associated with each of the 16 types, these are often broad descriptions which will require considerable interpretation by a hypermedia author, and in this respect are similar to many of the results of learning style instruments previously discussed (cf. 1.5.4). Additionally, the complexity and labour of authoring in 16 individual styles is less than practical.

One approach to making CAI authoring more systematic is to utilise the bipolar characteristics of the 4 scales of the MBTI. The literature reports that distinct learning style characteristics are associated with the 4 individual scales. These will be explained in detail below (for clarity, the scales of the MBTI are repeated in figure 5.1; see also 3.2.7 for an explanation of the types).

Orientation	EXTRAVERSION • INTROVERSION
Processes	SENSING • INTUITION
	THINKING • FEELING
Attitudes	JUDGMENT • PERCEPTION

Figure 5.1: MBTI scales (the scales termed mental processes are shown tinted)

In applying learning styles to the psychological types, the two scales termed *mental processes* (SENSING•INTUITION and THINKING•FEELING) are most important (cf. 3.3). These are shown tinted in fig. 5.1. The relative importance of these mental process scales is reflected by their use in the prioritising of preferences as explained in Chapter 3 (cf. fig. 3.3.1). In addition, I thought it likely that this use of the scales would facilitate the development of appropriate rules for computer implementation of learning materials in suitable styles.

5.2.1 Sources of data

The approach taken here has been to review the literature systematically with a view to finding relationships between psychological types — as measured by the MBTI — and learning preferences or styles. Among the most important distillations of relevant research findings are several works which provide the theoretical background to learning styles. These include Myers & Myers (1980); Lawrence (1993); and the MBTI handbook (Myers & McCaulley, 1985); additionally, Lawrence (1984) offers a comprehensive and detailed synthesis of learning style research involving the MBTI.

Overall, this literature search produced a large number of learning style characteristics that are associated with the individual MBTI scales. A full account of the more broadly-based characteristics — together with a commentary on the source documents — is provided in Appendix B. From these broad preferences, a smaller number of more specific characteristics has been extracted. These are preferences for learning which are reported consistently.

Lawrence (1984) has highlighted that studies which link learning styles with the scales of the MBTI sometimes provide *indirect* evidence of learning style differences between the 16 psychological types:

> "The evidence is considered indirect because the studies did not specifically measure differences in students' responses to particular learning situations or their preferences for different learning tools or situations."

However, the MBTI handbook (Myers & McCaulley, 1985), among other sources, reports many correlations between scales of the MBTI and the scales of other psychometric instruments. These correlations often give a distinct indication of learning styles and corroborate evidence from more indirect studies. Several of the stronger correlations will be reported in the tables below.

5.3 Specifications for CAI

It will be demonstrated here that utility can be derived from use of the MBTI scales, and that such a model will satisfy the requirements of learners for a form of CAI which will adapt to their most basic learning needs. The specific learning style preferences which have been selected as specifications for the authoring of CAI are presented in the tables below. These are proposed as specific delivery treatments under the following definitions:

- **Focus**: the primary characteristics which form the focus of a learner's viewpoint in a learning situation.

- **Exemplars**: these are examples, metaphors or demonstrations which represent and support this preference. They may be seen as evidence available to the learner which reinforces the character of the main preference.

- **Direction**: this indicates instructional direction, that is whether there is a preference for instruction which goes from parts to wholes (concrete ➔ abstract) or from wholes to parts (abstract ➔ concrete)[1].

- **Initiative**: initiative is concerned with whether there is a preference for control to be situated more with the learner or more with the computer system (cf. 4.4.2).

- **Structure**: the type of guidance and support structure for teaching materials — whether tuition is significantly constrained by structure and is guided (cf. 4.5.1 for linear systems), or whether there is more scope for exploration (cf. 4.5.2 for exploratory systems).

1 The terms *abstract* and *concrete* are as used in educational technology:
Abstract: "to separate by the operation of the mind, as in forming a general concept from consideration of particular instances; existing only as a mental concept; opposite to concrete"
Concrete: "denoting a particular thing; opposite of abstract" (Chambers 20th Century Dictionary); in the context of the MBTI scales, concrete is taken to mean that which is addressable by the senses.

The following table shows a summary of the definitions explained above and which form the basis for the proposed specifications for CAI preferences:

Focus		The primary characteristics which form the focus of a learner's viewpoint in a learning situation.
Pedagogy	**Exemplars**	These are examples, metaphors or demonstrations which represent and support this preference.
	Direction	This indicates instructional direction, that is whether instruction goes from parts to wholes (concrete → abstract) or from wholes to parts (abstract → concrete).
	Initiative	Initiative is concerned with whether control is situated more with the learner or with the computer system.
	Structure	The type of guidance and support structure for information and lessons, that is whether tuition is significantly structured and guided, or whether it is more exploratory.

Figure 5.2: Proposed specifications for CAI preferences and their interpretation

It should be noted that not all of the definitions will be fulfilled for every scale. Where there are no data, nil is entered shown by the symbol ' - ' (see for example fig. 5.3). Sources are referenced as a number in square brackets [ ]. These numbers relate to the list in the footnote below [2]. All sources are listed fully in the references section at the end of the thesis. A learning style attribute has been given usually where two or more authorities have demonstrated a link between a learning preference and a scale of the MBTI. Where possible, an indication of the strength of this link is also provided[3].

Following each of the CAI specification tables, the main points will be discussed.

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2 Source documents are cited in the tables by a single number, and are fully listed in the reference section at the end of this thesis:
[1] Myers & McCaulley 1985; [2] Myers & Myers 1980; [3] Myers 1993; [4] Keirsey & Bates 1978; [5] Lawrence 1993; [6] Stricker & Ross 1962; [7] McCaulley 1978; [8] Hoffman, Waters & Berry 1981; [9] Kilmann & Taylor 1974; [10] Martray 1971; [11] Myers 1962; [12] Lawrence 1984; [14] Eggins 1979; [15] Golanty-Koel 1977; [16] Griesen 1971; [17] Harrison 1984; [18] McCaulley & Natter 1974; [19] Nisbet, Ruble & Schurr 1981; [20] Nisbet, Ruble & Schurr 1982; [21 Pratt, Uhl & Little 1980; [22] McCrae & Costa 1989; [23] Clarke 1993; [24] McCaulley 1990; [25] Margerison & Lewis 1981; [26] Roberts 1982; [27] Smith & Irey 1974; [28] Yokomoto & Ware 1982; [29] Ross 1961; [30] Smith, Irey & McCaulley 1973; [31] Jensen & DiTiberio 1984; [32] McCaulley 1981; [33] Otis 1972; [34] Carlson & Levy 1973; [35] Peters 1981

3 Where correlations are reported between MBTI scales and those of other psychometric instruments, the strength of correlation is shown by asterisks as follows:
** denotes that p<.01
*** denotes that p<.001
Other, weaker correlations are not listed.

5.3.1 CAI specification for EXTRAVERSION

CAI for EXTRAVERSION - proposed specification		
Focus		Activity and action in the outer world [1, 2, 3] Need for verbalising, discussion, learning by talking [1, 3, 5, 6**, 8, 9, 11**, 27] Working in a group; seeing what others are doing [1, 3, 5, 7***, 8, 9]
Pedagogy	**Exemplars**	-
	Direction	-
	Initiative	-
	Structure	-

Figure 5.3: Proposed specification for CAI preferences — EXTRAVERSION

5.3.2 Discussion of EXTRAVERSION learning style

The learning style associated with EXTRAVERSION is characterised by a preference for group activity, through discussion and interaction with others, and by verbalising ideas (Lawrence, 1984; Myers & McCaulley, 1985). Stricker & Ross (1962) have reported significant *talkativeness* related to EXTRAVERSION, as did Myers (1962)[4]. McCaulley (1978) reported a very strong correlation with the term "likes being with people"[5]. To match EXTRAVERSION to CAI might entail, for example, group collaborative work through such means as networking, or for the lesson to be part of a wider project where experiences could be shared with others face to face (either in real or virtual environments). For example, Lawrence (1984) states:

> "Extraverted students in a military training short-course on Morse code had a disproportionately high dropout rate until certain course changes were made. The changes included the option of two or three students being together on one computer terminal, and more frequent question-discussion sessions and mini-lectures. After the course changes, there was no significant interaction of type and dropping out" (Hoffman, Waters & Berry, 1981).

In the context of this thesis, where a learner works alone[6], there is no learning style effect identified with EXTRAVERSION. EXTRAVERSION is highly represented in designers at 72% (cf. 3.5.3).

4 All these studies utilised the Omnibus Personality Inventory (OPI) (Heist, McConnell, Webster & Yonge 1963).

5 Omnibus Personality Inventory (OPI) Social Extraversion scale (Heist, McConnell, Webster & Yonge 1963).

6 A standalone, self contained computer teaching package was defined earlier (cf. 1.1). This was defined as not forming part of a wider learning project or programme, and does not involve team working, ie. it is restricted to learner plus computer.

5.3.3 CAI specification for INTROVERSION

CAI for INTROVERSION - proposed specification		
Focus		Reflection before action [1, 3, 25] Need for privacy in learning; working individually [1, 3, 4, 5, 8] Reading, bookish [3, 4, 5, 10] Self sufficient; independent learning [1, 7***, 11**]
Pedagogy	**Exemplars**	-
	Direction	-
	Initiative	Pace of learning set by the learner [5, 10]
	Structure	Need to concentrate over long periods; no interruptions [3, 25] Opportunities for depth & detail [3, 25]

Figure 5.4: Proposed specification for CAI preferences — INTROVERSION

5.3.4 Discussion of INTROVERSION learning style

The learning style associated with INTROVERSION is characterised by a preference for the maintenance of privacy in learning, where there may be a considerable amount of learning through reading, and where deep processing of materials requires time for reflection (Lawrence, 1984; Myers & McCaulley, 1985). These learners have a preference for setting the pace of delivery, and to study without interruption for as long as they need.

Self study with CAI may therefore naturally suit those preferring INTROVERSION. In particular, learners preferring INTROVERSION exhibit a degree of independence in studying. For example, both Myers (1962) and McCaulley (1978) found strong correlations with *self-sufficiency* scales[7].

In this context it should be noted that one profession which *chooses* to work with computers is represented by computer professionals (cf.3.4.10): of these, 67% prefer INTROVERSION.

7 Myers used the Personality Research Inventory (PRI) (Saunders 1955). McCaulley used the Sixteen Personality Factor Questionnaire (16PF) (Cattell, Eber & Tatsuoka 1970) in a study involving large samples.

5.3.5 CAI specification for SENSING

CAI for SENSING - proposed specification		
Focus		Practical and realistic [1, 3, 4, 5, 12, 29, 32] Details; specifics [4, 5, 8, 14, 24, 25]
Pedagogy	**Exemplars**	Facts and details; concrete; concepts made explicit [3, 4, 15, 25, 28] Practical outcomes; practical data; solutions to problems [4, 32] Measurements; economic data [1, 11**, 32]
	Direction	Concrete to abstract; parts to wholes; start with verifiable and familiar facts, then progress to concepts and ideas [1, 3, 31]
	Initiative	-
	Structure	Sequential instruction; step by step [3, 5, 8, 14, 18, 23, 24, 25] Opportunities to repeat lessons; practice memorisation [5, 8, 15, 27]

Figure 5.5: Proposed specification for CAI preferences — SENSING

5.3.6 Discussion of SENSING learning style

The learning style associated with SENSING is characterised by a realism and practicality, and regards as important that information which is directly addressable by the senses (Lawrence, 1984; Myers & McCaulley, 1985). Therefore factual information is preferred, along with details. Myers (1993) shows SENSING types to prefer also educational information which is delivered in a linear manner, step by step. Linked with this is a requirement for opportunities to have lessons repeated and to practice memorising data (summarised in Lawrence, 1993). This seems related to the drill-and-practice type of CAI systems (sometimes known as *programmed learning*) which are successful with certain kinds of learning task and learner (cf. 4.2.8).

Myers (1993) reported the SENSING•INTUITION scale to be important as an indicator of the *direction* of learning. Lawrence (1984; 1993) has conjectured that learners for whom SENSING is a dominant preference learn best when their lessons firstly present them with concrete facts, and then move towards abstraction and concepts. This is confirmed to a large extent by the series of studies by Jensen & DiTiberio (1984) which showed that SENSING types prefer to start with factual, verifiable data, together with what they have already learned: additionally, irrelevant facts require to be sorted from the relevant. It has also been demonstrated by Eggins (1979; discussed in Myers & McCaulley, 1985) that SENSING students learned better with

an instructional model by Gagné which presents a linear structure. This style of learning may be compared favourably with that of the serialist (cf. 2.5.3) and of appropriate serialist treatments proposed by Clarke (1993).

Myers (1962) showed sensing to be strongly related to *economic interests*[8].

One related problem which SENSING types may have is difficulty in generalising from facts. Yokomoto & Ware (1982) reported SENSING engineering students who had been taught successfully to master specific examples and then look for connections and patterns.

A general population comprises about 76% SENSING types. A majority of business managers (67%), engineers (58%), and military personnel (65%) have a SENSING preference. On the other hand, only 21% of representative designers preferred SENSING.

8 Allport-Vernon-Lindzey Study of Values (AVL) (Allport, Vernon & Lindzey 1960).

5.3.7 CAI specification for INTUITION

CAI for INTUITION - proposed specification		
Focus		Future orientated [1, 3, 4] Ideas, imaginings, possibilities [1, 4, 5, 7***, 11**, 17, 25,] Significant reading [1, 15, 12, 18, 26] Independent; enjoy self-instruction [1, 5, 6***, 8, 14, 18, 33] Openness [22***]
Pedagogy	**Exemplars**	General impressions and concepts [5, 27, 28] Alternative viewpoints [1, 35]
	Direction	Abstract to concrete; wholes to parts; big picture first, then progressing towards details and facts [1, 3, 23, 24, 31]
	Initiative	Learner's own pace [3, 18, 30, 34]
	Structure	Light guidance [14] Relationships and common characteristics; associations [5, 14, 28] Need for choice; variety [3, 25] Experimenting [7***]

Figure 5.6: Proposed specification for CAI preferences — INTUITION

5.3.8 Discussion of INTUITION learning style

The learning style most associated with INTUITION is characterised by an orientation towards future possibilities and imaginings (cf. 3.2.5; Lawrence, 1984; Myers & McCaulley, 1985). McCaulley (1978) reported a strong correlation with *imagination*[9], and similarly Myers (1962) found a significant relationship to *artistic* (versus *practical*)[10].

There is a special interest in reading, and INTUITION types consistently show facility with speed and comprehension (discussed in Lawrence, 1984).

McCaulley & Natter (1974) presented evidence for a markedly independent attitude towards learning, for example with questions such as:

> "Self instructional courses help me" ($p<.01$)
> "I like courses that throw me on my own initiative" ($p<.001$)

This accords with the findings of Stricker & Ross (1962) of *achievement via independence*[11].

9 Sixteen Personality Factor Questionnaire (16PF) (Cattell, Eber & Tatsuoka 1970).
10 Personality Research Inventory (PRI) (Saunders 1955).
11 California Psychological Inventory (CPI) (Gough 1975).

Myers & McCaulley (1985) state that INTUITION types learn best from lessons which present them firstly with concepts (the big picture) and only then work towards concrete facts: therefore they prefer a learning model which goes from abstract to concrete, and which may provide alternative viewpoints (Peters, 1981). INTUITION is also associated with a more holistic approach to learning such as that proposed by Clarke (1993); the seeing of patterns and relationships between data (Lawrence, 1993); with several other aspects of academic aptitude[12]; and with creative and artistic endeavour or interests[13]. These preferences may also be linked with the strong correlation with *experimenting (radicalism)* reported by McCaulley (1978)[14].

INTUITION types have been shown to benefit most from an instructional model which offers a less-structured, inductive approach (Eggins, 1979). However, Myers (1993) has shown that by relying solely on concepts, INTUITION types may miss important details. Margerison & Lewis (1981) have also indicated a preference for genuine choice and variety.

A general population comprises only about 24% of INTUITION types. In contrast, most designers and cognate professionals have INTUITION as a significant preference (cf. 3.4.4; 3.4.5; 3.4.6; 3.5.3). In the case of the *most* creative architects it was 100% INTUITION. Fine artists (91%) are closely followed by representative architects (82%) and representative designers (79%). In a review of the literature on creativity Barron (1965) called INTUITION the quality *par excellence* for creative endeavour. It can be seen as such from these data (at least for the *kind* of creativity which designers have).

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12 On academic aptitude tests, INTUITION types earn higher grades — it is thought that the tests are not designed to assess the intelligence of the more practical SENSING types. INTUITION types are in the majority in programmes for the gifted (USA), and account for between 60-100% of creative arts samples. Relatively more INTUITION types enter Higher Education so SENSING and INTUITION are about equally distributed in college samples (Myers & McCaulley, 1985).

13 N is widely reported to be related to creativity, and is often coupled with P in this respect. For example, it has been found to be skeptical and *rejecting of orthodoxy* at the level of p<.001 (McCaulley, 1978); linked with *aesthetics* (Myers, 1962); and linked with *artistic theme and art interests* at the level of p<.001 (Lacy, 1984).

14 From a large sample using the Sixteen Personality Factor Questionnaire (16PF) (Cattell, Eber & Tatsuoka 1970) p<.001.

5.3.9 CAI specification for THINKING

CAI for THINKING - proposed specification		
Focus		Analytical; logical; objective [1, 3, 4, 24, 25] Impersonal basis for decisions [1, 3, 4, 25] Thing-centred [2, 25]
Pedagogy	**Exemplars**	Inanimate objects [2, 25] Analysis; critical appraisal [3, 4, 24, 25] Standards; principles; rules [3, 4, 25] Theories [7***, 32] Objective materials [4, 5, 18, 30]
	Direction	-
	Initiative	-
	Structure	Need for goals and performance criteria to be declared [1, 30] Teacher lectures and demonstrations [18, 34, 30] Logical structure to teaching [5, 30]

Figure 5.7: Proposed specification for CAI preferences — THINKING

5.3.10 Discussion of THINKING learning style

The learning style associated with THINKING is characterised by objectivity, allied with logical analysis (Myers & McCaulley, 1985). This strives to be an impersonal basis for decision-making, and Myers & Myers (1980) showed THINKING types to be focused more towards inanimate objects than towards people: they may therefore be said to be *thing-centred*. In CAI, this may mean that opportunities exist for analogies or examples related to the products of technology, or possibly to the built environment.

THINKING favours exemplars showing objective data such as standards and principles (Myers, 1993). McCaulley (1978) found a strong correlation between THINKING and a *theoretical* scale[15] though other studies have linked this to INTUITION+THINKING (NT)[16]. Thinking types seem to be more accepting of lectures and demonstrations (eg. McCaulley & Natter, 1974). Lawrence (1993) has linked this analytical approach to a preference for a form of tuition where the structure can be seen to be logically arranged.

15 From the Allport-Vernon-Lindzey Study of Values (AVL) (Allport, Vernon & Lindzey 1960) the correlation between THINKING and the *theoretical* scale was $p<.001$.

16 Studies using the Study of Values (AVL) (Allport, Vernon & Lindzey 1960). However, McCaulley's study was conducted with a mixed-gender group, whereas other studies (summarised in Myers & McCaulley, 1985) were of all-male groups.

In human-computer-human communications, it has been shown that people are incorrectly perceived as being more analytical than they really are (cf. 4.3.8): this equates to being perceived as more THINKING. Thimbleby (1990) suggests that as most interactive systems are written in imperative languages, a THINKING style develops naturally because of the analysis and planning required in the implementation of algorithms (cf. 4.1). The propositional mode of THINKING may therefore be more natural as a computing style. 81% of computer specialists were shown to prefer thinking. This is also consistent with a THINKING process being preferred by the great majority of business managers (75%), engineers (70%), and to a lesser extent, military personnel (60%).

5.3.11 CAI specification for FEELING

CAI for FEELING - proposed specification		
Focus		Personalistic value judgments [1, 3, 4, 25] Person-centred [1, 4, 22, 35] Subjectivity [1, 4, 25]
Pedagogy	**Exemplars**	Values (eg. good/bad; beautiful/ugly etc) [24, 25] People's needs; effects upon people [1, 3] Attend to beliefs or traditions [11, 25]
	Direction	-
	Initiative	-
	Structure	Feedback with personal encouragement [3, 5, 30]

Figure 5.8: Proposed specification for CAI preferences — FEELING

5.3.12 Discussion of FEELING learning style

The learning style associated with FEELING is characterised by a comfort with value judgments which are often personalised (Myers & McCaulley, 1985): this is a more personal basis for decision-making, and FEELING types tend to be focused towards people. This may mean that opportunities exist for analogies or examples related to case studies involving people, the effects of (for example) technology upon people, and possibly the natural environment.

There are few correlations of FEELING with scales of other instruments which might indicate preferences for learning. Myers (1962) showed a correlation with a *social* scale[17]. Several other studies have similarly reported person-related aspects of FEELING, for example it has been linked with an *agreeableness* factor (McCrae & Costa, 1989)[18]. However, these relationships do not shed further light on learning preferences[19].

Peters (1981), in a carefully constructed study of style preferences in texts, classified several written texts (about aspects of education) in relation to the MBTI scales. These were then compared with MBTI types where persons were both

17 Allport-Vernon-Lindzey Study of Values (AVL) (Allport, Vernon & Lindzey 1960) p<.01.
18 Using the Five Factor Model of Personality (5FP) (McCrae & Oliver 1992).
19 For discussion of these issues see Myers & McCaulley (1985); and Lawrence (1984).

matched and mismatched with the texts[20]. He states that FEELING respondents were:

> "enthusiastic about action-oriented research strategies aimed at solving 'real-world', people-oriented problems. Unlike the two thinking types, however, [they] consistently cited the 'personal' tone of the two feeling articles as especially appealing."

Peters goes on to state that perhaps more significant than *what* these students preferred were the *reasons* they gave for their preferences. For example, one FEELING type, discussing an article classified as THINKING (plus SENSING) said:

> "I do not like the charts and mathematical representations of information. This kind of research seems cold and unfeeling and of little value."

Another FEELING respondent stated that they had no interest in the same article:

> "because it is so dry and sterile. I would not enjoy analysing the data."

However, a FEELING respondent, when commenting on reading a FEELING article, said:

> "Unscientific maybe, but probably more personally meaningful from most other approaches. Makes people think about what they are doing — at the gut level — not just as theoretical garbage as is so much in education." *(underlining is in the original)*

Because of their natural empathy with other people, FEELING types prefer some feedback on their learning which is personal and offers encouragement (Myers, 1993).

From the samples reported in Chapter 3 only the fine artists (cf. 3.4.5) show a large majority in favour of FEELING (70%). Interior designers are less so (61%). It should also be noted that fine artists combine strong preference for FEELING with INTUITION (NF), with some 65% having these two characteristics in combination.

20 This highly statistical analysis was conducted with texts and individuals classified as ST; NT; ST; and NF. Individuals commented on each text (one of which was theoretically matched to their type) by responding to a questionnaire.

5.3.13 CAI specification for JUDGMENT

CAI for JUDGMENT - proposed specification		
Focus		Formal; serious [4, 5, 16, 19, 20, 24] Need for closure; matters settled [1, 3, 4, 5, 8, 30] Achievement by conformance [6***]
Pedagogy	**Exemplars**	-
	Direction	-
	Initiative	-
	Structure	Goals, deadlines made explicit [3, 4, 24, 25, 31] Orderly; structured presentation; scheduled [3, 5, 18, 19, 20, 25, 30, 34] Consistency; predictability [1, 25] Celebration of learning progress [3, 5]

Figure 5.9: Proposed specification for CAI preferences — JUDGMENT

5.3.14 Discussion of JUDGMENT learning style

The learning style associated with JUDGMENT is characterised by Lawrence (1993) as being most comfortable when matters are settled and where goals and deadlines are made explicit. Nisbet, Ruble & Schurr (1982) found a preference for more formalised, traditional instruction and a desire for predictable academic routine. Additionally, small celebrations of progress may be welcomed (Myers, 1993).

JUDGMENT types are relatively comfortable with formality in learning (Keirsey & Bates, 1978) and this was reported by Stricker & Ross (1962) to be strongly correlated with *achievement via conformance* [21]. Beyond this there are no other significant correlations with other scales which throw light on related learning styles.

In contrast to representative designers of whom 69% prefer PERCEPTION, many other groups show a marked preference for JUDGMENT. Preference for judgment is highest in business managers (76%), followed by computer specialists (66%), engineers (62%), and military personnel (59%).

21 Using the California Psychological Inventory (CPI) (Gough 1975) p<.001. This study was conducted with a sample of 713 males. A sample of 1218 of both sexes showed a correlation with E+J, though J was still significant at the level p<.001.

5.3.15 CAI specification for PERCEPTION

CAI for PERCEPTION - proposed specification		
Focus		Exploratory; curious; playful [3, 4, 24, 25] Openness; flexibility; change [1, 3, 4, 5, 8, 9, 11**, 22, 24, 25] Information gathering [25, 31]
Pedagogy	**Exemplars**	-
	Direction	-
	Initiative	Learner control of pace and choice [3]
	Structure	Open; changeable [3, 5] Allowing exploration; impulsive search; discovery [4, 5, 8, 14, 25, 29]

Figure 5.10: Proposed specification for CAI preferences — PERCEPTION

5.3.16 Discussion of PERCEPTION learning style

The learning style associated with PERCEPTION is characterised by curiosity and exploration of information (Myers, 1993), and by copious information gathering (Margerison & Lewis, 1981).

There is a willingness to be flexible in learning, and an openness and effectiveness in identifying issues (Kilmann & Taylor, 1974).

There are few correlations with the scales of other instruments which indicate learning preferences. Myers (1962) reported a significant correlation with *change*[22]. Especially when allied with INTUITION, PERCEPTION is significantly correlated with *flexibility* eg. Stricker & Ross (1962)[23]. In respect of flexible information gathering, PERCEPTION preferences may be equated with *hypertext* techniques ie. the linking of information in more freeform, associational ways which invite exploration and discovery.

Myers (1993) reported that students who share INTUITION+PERCEPTION (NP) are especially likely to enjoy independent study programs. PERCEPTION was preferred by 69% of representative designers. 55% of representative designers were NP.

22 Edwards Personality Preference Survey (EPPS) (Edwards 1959) p<.01.
23 California Psychological Inventory (CPI) (Gough 1975) p<.001.

5.4 The CAIUS model

The CAI specifications can now be brought together into a proposed model of computer aided instruction using styles (CAIUS)[24]. This will be based upon the MBTI matrix established in chapter 3 (cf. 3.3). The CAIUS model is two-dimensional, and the axes will be described in detail as follows.

5.4.1 The role of EXTRAVERSION•INTROVERSION

It is firstly important to clarify the role played by the E•I scale. At first sight it seems that there are no learning style effects arising from these preferences (cf. 5.3.1; 5.3.3) though EXTRAVERSION does of course feature in setting the dominance of the mental processes (cf. 3.3).

EXTRAVERSION learning is characterised by a need for action involving other people, by talking and discussion. This may involve learning in a group with others. Those who prefer EXTRAVERSION also find that verbalising ideas helps them, by talking out loud about concepts and ideas. This suggests the use of computer-supported collaborative working. It is possible that more immersive environments and the use of technologies such as telepresence[25] would provide a more direct interaction with other persons through the medium of the computer. However, these are beyond the scope of the present investigation. With present forms of stand-alone hypermedia, satisfying these requirements will need further research.

INTROVERSION, on the other hand, favours many of the characteristics of CAI: it allows reflection and maintains privacy in studying. CAI can provide individual ways of learning, the pace may be set by the learner, and those preferring INTROVERSION are able to concentrate on study for long periods. INTROVERSION seems well served by CAI. There are however no additional learning style effects arising from E•I[26].

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24 Pronounced *ki'us*

25 People interacting with each other through the use of computer-mediated video, sound etc. but geographically separated.

26 The effect of E•I on the dominant process is explained in detail in the MBTI handbook (Myers & McCaulley, 1985).

5.4.2 Horizontal axis

The horizontal axis reflects the scale SENSING to INTUITION (cf. 5.3.5; 5.3.7).

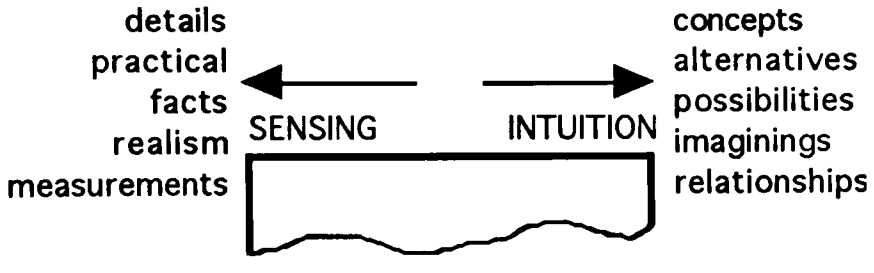

Figure 5.11: Horizontal axis, SENSING to INTUITION

SENSING learners prefer

- practicality and realism; what is known to be possible
- facts; details; concrete examples
- practical data and outcomes
- measurements; economic data
- linear instruction

INTUITION learners prefer

- ideas and possibilities; imaginings; what might be possible
- impressions and concepts
- alternative viewpoints
- relationships and associations

The horizontal axis therefore reflects

- a differential from the more practical to the more imaginative
- a differential from the more detailed to the more conceptual

The horizontal axis also reflects preference for instructional direction (cf. 5.3.6)

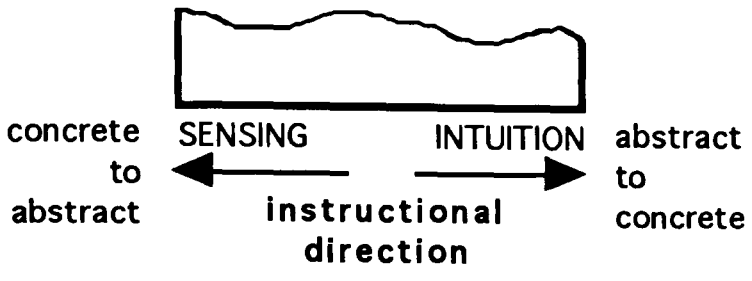

Figure 5.12: Horizontal axis, instructional direction

SENSING learners prefer

- instruction which begins with the facts and details, then generalises to the concepts. This form of instruction therefore progresses from concrete to abstract.

INTUITION learners prefer

- instruction which begins with concepts, and works towards the facts and details. This form of instruction therefore progresses from abstract to concrete.

The horizontal axis therefore reflects instruction which is either

- concrete→abstract in direction, or
- abstract→concrete in direction

The JUDGMENT • PERCEPTION scale reflects preferences for control of learning, and to an extent structure, and may therefore be mapped to the horizontal axis (cf. 5.3.13; 5.3.15).

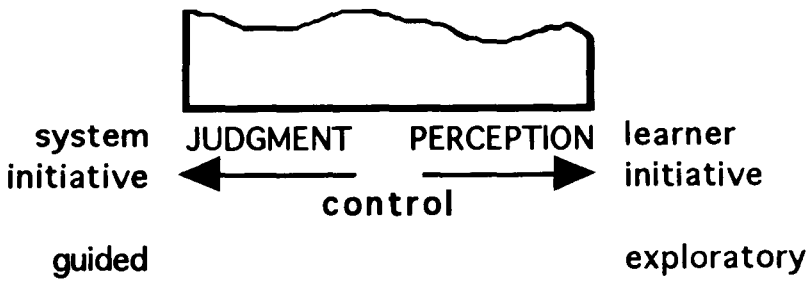

Figure 5.13: Horizontal axis, control

JUDGMENT learners prefer

- a more guided structure, with predictability and consistency
- learning goals made explicit
- celebrations of progress

PERCEPTION learners prefer

- a more open structure a which allows exploration and information gathering
- control exercised more by the learner

The horizontal axis therefore reflects

- a differential from system initiative to learner initiative
- a differential from more guided structure to exploratory structure

5.4.3 Summary of the horizontal axis

The learning styles specific to the horizontal axis of the CAIUS model may be summarised as follows:

- a differential from the more practical and detailed, to the more imaginative and conceptual

- instruction which is either concrete➞abstract, or abstract➞concrete

- a differential from system initiative with a more guided structure, to learner initiative with a more exploratory structure

5.4.4 Vertical axis

The vertical axis reflects the scale THINKING to FEELING (cf. 5.3.9; 5.3.11)

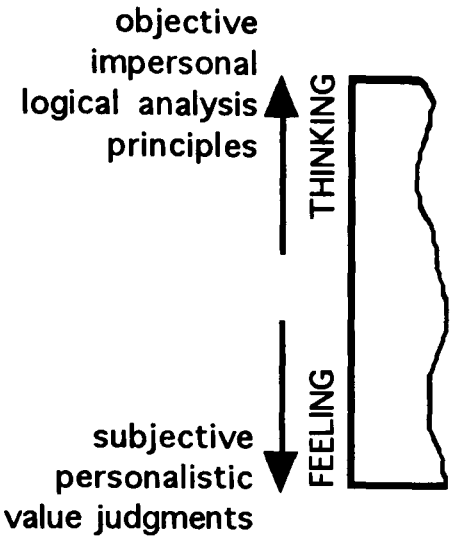

Figure 5.14: Vertical axis, THINKING to FEELING

THINKING learners prefer

- objective materials; detached impersonality
- logical analysis; critical appraisal
- standards and principles; theories

FEELING learners prefer

- more subjective materials
- more personalistic value judgments

The vertical axis therefore reflects

- a differential from objective analysis to more subjective values

The vertical axis also reflects preference for certain kinds of exemplars (cf. 5.3.10; 5.3.12). These may be defined as any examples used, eg. artifacts etc.

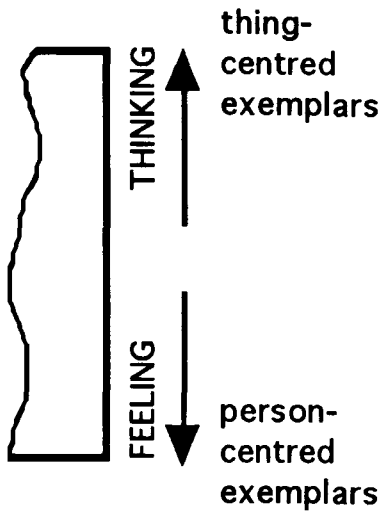

Figure 5.15: Vertical axis, exemplars

THINKING learners prefer

- exemplars that are centred on inanimate objects (thing- or product-centred)

FEELING learners prefer

- exemplars that relate to people (people-centred)

The vertical axis therefore reflects

- a differential from thing-centred examples to people-centred examples

5.4.5 Summary of the vertical axis

The learning styles specific to the vertical axis of the CAIUS model may be summarised as follows:

- a differential from objective analysis and examples of things, to more subjective values with examples which are centred on people

5.4.6 The CAIUS 16-styles model

Putting all the above specifications together provides a composite CAIUS model which is capable of providing appropriate instruction for 16 types of learner.

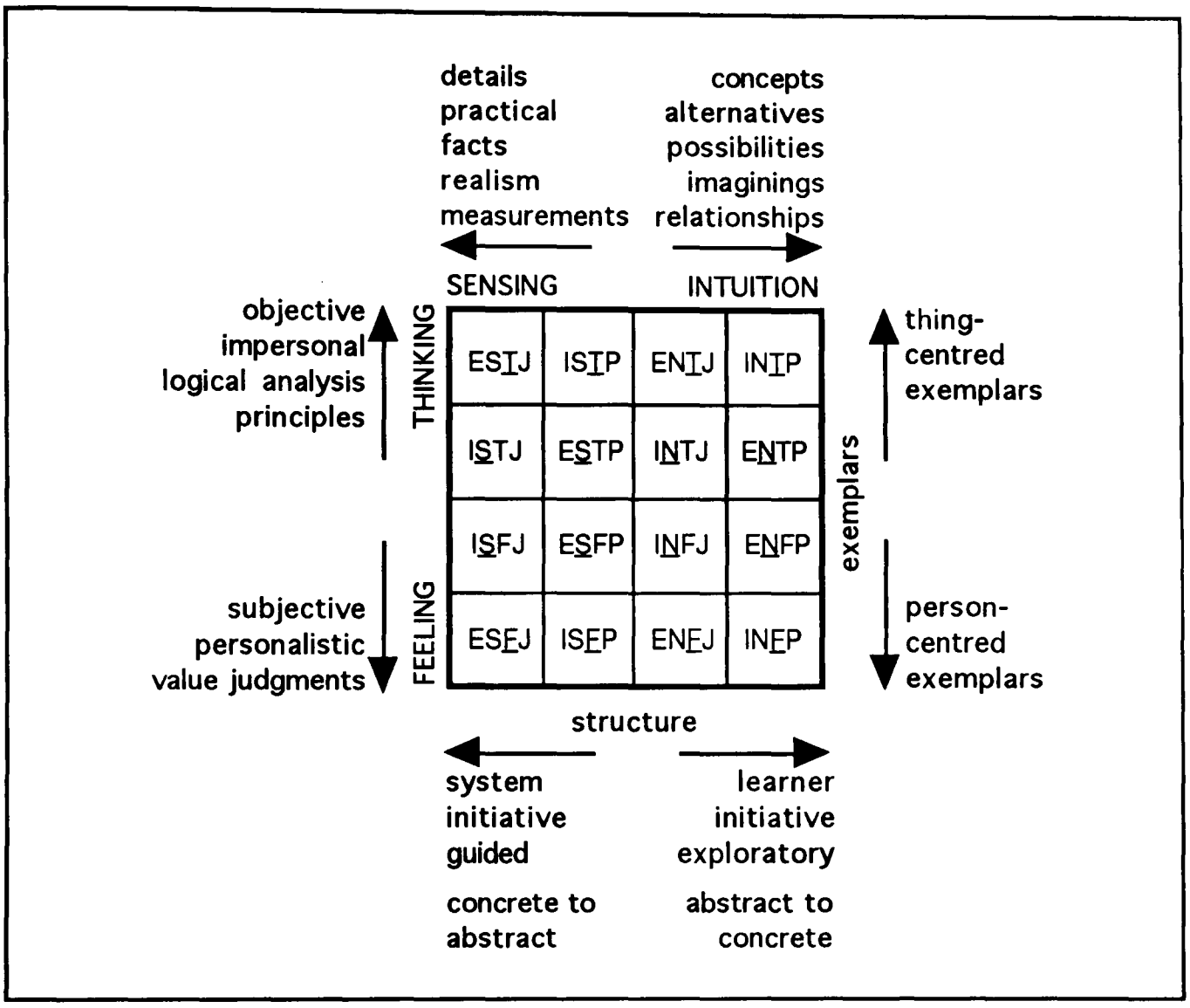

Figure 5.16: CAIUS model, 16-types

5.5 Features of the CAIUS model

In summary, this model brings together the following

- **Focus**:

  from the more practical to the more imaginative

  from the more detailed to the more conceptual

  from objective analysis to more subjective values

- **Direction** : either concrete to abstract or abstract to concrete

- **Initiative** :

  from system initiative to learner initiative

  from more guided to more exploratory

- **Exemplars** : either thing-centred or people-centred

5.5.1 Instructional models

There are many models of instruction which seek to structure the content and delivery of educational materials based on various educational theories. Authors of distance learning materials have devised particular ways to encourage motivation without direct teacher interaction. There may be careful crafting of knowledge within the context of a specialist subject domain. It is not the intention of the CAIUS model either to diminish or to supersede these practices. CAIUS is intended only as a vehicle for getting educational materials into a computer implementable form, and for delivering these in a variety of styles consonant with the learning preferences of target students[27]. CAIUS may be considered as a support structure at the *micro* level which applies style preferences through structure, control, and examples. At the *macro* level (ie. overall lesson design) all the tools in the pedagogue's toolbox may still be utilised. These are not (yet) a part of the CAIUS proposals.

5.5.2 Use of the quadrants

Myers (discussed in Myers & McCaulley, 1985) had envisaged that certain subgroups of the MBTI matrix would prove useful, for example where career choices are concerned. In this respect she conjectured the use of the *quadrants* which are formed by combinations of the 2 mental processes scales SENSING•INTUITION and THINKING•FEELING. This produces 4 basic groups which are a subset of the 16 type matrix. These are SENSING+THINKING (ST); SENSING+FEELING (SF); INTUITION+THINKING (NT); and INTUITION+FEELING (NF).

27 Though it does embody a simple instructional model (concrete/abstract and abstract/concrete) predicated on SENSING• INTUITION and which is intrinsic to the CAIUS framework.

These are shown (fig. 5.17) overlaying the 16 styles.

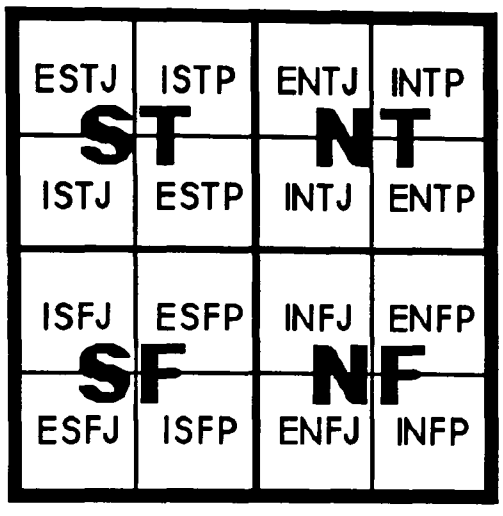

Figure 5.17: The quadrants

In the context of this thesis, the quadrants demonstrate two features concerning occupational groups and a simplified 4-style model.

5.5.3 Occupational groups

Firstly, the quadrants reflect the broad focus of occupational groups, thus showing designers and cognate professionals in relation to other professionals.

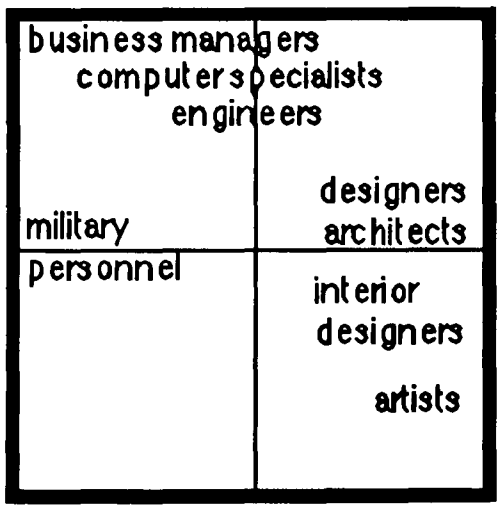

Figure 5.18: Relative positions of some occupations

5.5.4 Simplified model

Secondly, the quadrants represent a much simplified model of learning styles. This is capable of providing appropriate instruction for 4 types of learner. This model is shown as follows.

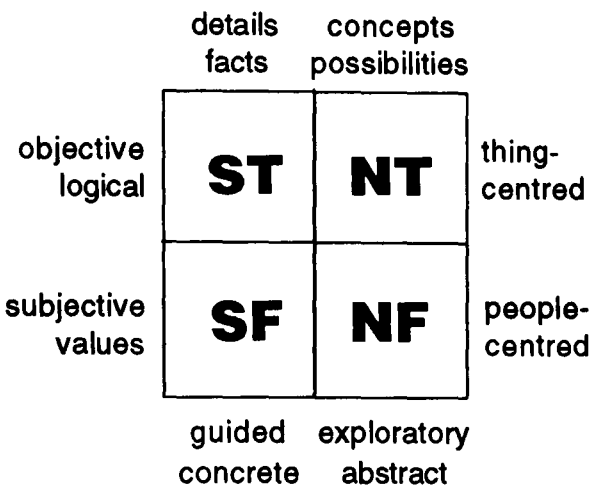

Figure 5.19: Simplified 4 styles model

5.5.5 Assessing the learner

The full CAIUS model offers the user an opportunity to select from 16 styles of learning. Once the user is conversant with their preferred style of interaction they may make an informed choice. However, new users will have to be supported in making an initial choice. Several opportunities to enter the system may be conjectured, ranging from direct user choice through to computer audit[28] and computer-initiated suggestions for suitable treatments. The following is a list of likely transactions based upon the user's knowledge of the system, ranked from least knowledgeable to most knowledgeable. These are shown diagrammatically in Fig. 5.20.

- **Quadrants**: the learner has no knowledge of his/her learning style, but plays with the system beginning with the quadrant s/he finds most attractive at that moment: these actions may be random. Subsequent computer audit could then suggest the most suitable (of 4 or 16) treatments based on the user's preferences in actually using the system.

28 Continuous assessment of the student's preferences by tracking of the paths consistently used by the individual (Jonassen, 1988).

- **Occupations**: the learner chooses from a pick list of occupations. This might begin at the quadrant level, and one of four styles could be offered. Subsequent computer audit could then suggest the most suitable (of 4 or 16) treatments based on the user's preferences in actually using the system.

- **Questionnaire**: the learner is assessed by a questionnaire[29]. The computer then matches the result to what it assesses as the most suitable of 16 treatments.

- **Matrix**: the learner knows their preference type (1 of 16) on the CAIUS matrix and selects it directly.

Novice users can therefore be assisted in finding a learning style which matches their preferences, or they will be able to explore available styles until they find one that suits them. The experienced user, on the other hand, will be able to click quickly into their preferred style. All users, even when best-match styles are being used, will be able to explore alternatives and to experience the same lesson from different viewpoints.

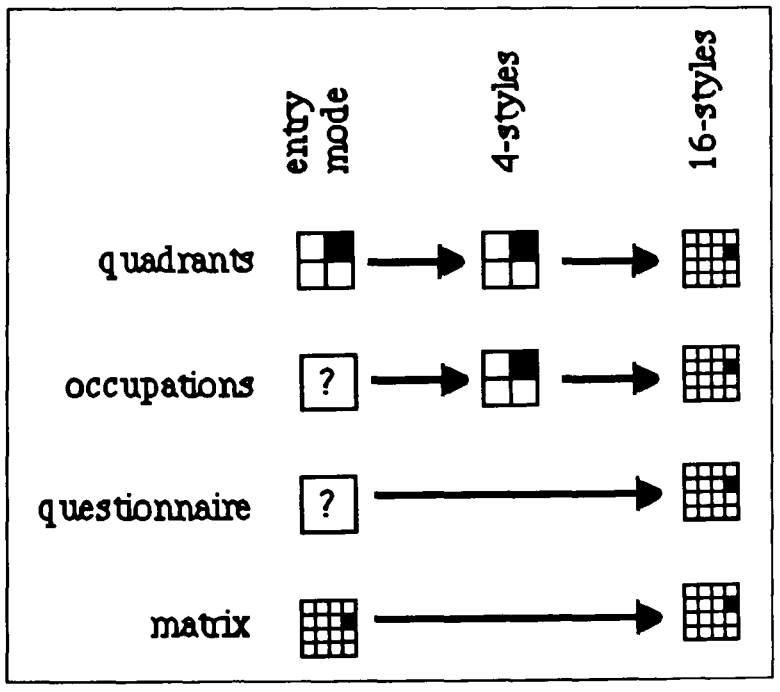

Figure 5.20: Learner selection and assessment

29 This could be achieved by a self scoring questionnaire for classifying persons into one of 16 psychological types such as the *sorter* developed by Keirsey and Bates (1978) or perhaps the MBTI form AV (Myers & McCaulley 1985). The *sorter* probably has sufficient accuracy for this task, and can easily be scored by computer.

5.6 An instantiation of CAIUS

Following the CAI specifications and description of the model, the following is an attempt to outline a structure which conforms to the specifications and which defines the delivery of educational materials matched to a total of 16 learning styles. This represents but one[30] instantiation of the CAIUS matrix in a teaching and learning model. It is a much simplified scheme intended to demonstrate only the most basic elements. It is not intended that this describes a complete lesson, but seeks to outline a structure which can be seen to operate at the level of nodes and links and introduce a number of building blocks that could make up a lesson.

5.6.1 Definitions

The terms to be used will now be defined, and will build upon the terms introduced in Chapter 4 for control (cf. 4.4); instructional systems (cf. 4.5); and information resources (cf. 4.6).

5.6.2 Nodes

A node has been defined as a point of information (cf. 4.5).

5.6.3 Goals

Goals are the target learning outcomes of this lesson. They may explicitly state what can be expected to be learned from this lesson, for example

- provide the context; review previous section(s)
- outline the spread of material in this section; mention any deadlines or tasks
- state what the learner should know at the end of this section

Goals are a requirement of THINKING and JUDGMENT. The icon for goals is as follows

Figure 5..21: Goals

30 Being INTUITION dominant, I am prepared to conjecture several proposals, all of them feasible, but life is short...

5.6.4 Mileposts

Mileposts are points at which progress is recapitulated explicitly and progress is celebrated. They may state what has been achieved so far, for example

- review what has been learned in this section
- set this learning in the context of the whole lesson
- congratulate the learner

Mileposts are a requirement of JUDGMENT. The icon for mileposts is as follows

Figure 5.22: Mileposts

5.6.5 Browsers

The *browser* may be conceptualised as a database used as a supporting resource for the searching and finding of information. Following the taxonomy defined in Chapter 4 (cf. 4.6) this is of two types, *tree* and *hypertext* (associational). These incorporate hierarchical indexing and hypertext searching respectively.

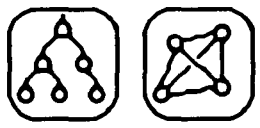

Figure 5.23: Tree browser, and hypertext browser

5.6.6 Direction

The preference for *direction* of learning is determined by SENSING (concrete ➔ abstract), or INTUITION (abstract ➔ concrete).

5.6.7 Frames

At each node is a number of *frames* showing *exemplars.* The exemplars support a particular topic. Exemplars are a requirement of the processes scales of SENSING • INTUITION and THINKING • FEELING. Frames for a given topic are authored in 4 styles relating respectively to facts/present (S), ideas/futures (N), analysis/things (T), and values/people (F). These may be simple frames or be expanded by the use of hotspots or similar devices to link to further information on the topic, authored in

the same style. The icon for a frame (in this case authored in the style of SENSING) is as follows

Figure 5.24: Exemplar frame (in the style of SENSING).

5.6.8 Sequence of frames

Frames are presented to the learner in a particular *sequence*. Sequencing is determined by dominance (cf. 3.3.1). Frames are presented in one of two ways:

- a *fixed* sequence where they must be viewed in the order shown. This is typical of linear, programmed learning techniques.
- a *suggested* sequence where the learner has choice of the order of viewing. This is typical of more exploratory instructional systems.

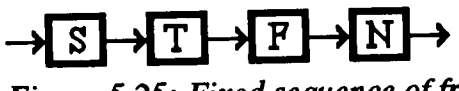

Figure 5.25: Fixed sequence of frames

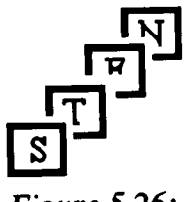

Figure 5.26: Suggested sequence of frames

5.6.9 Authoring exemplar frames

What might windows look like?

A main benefit of the CAIUS model is that, by authoring exemplar frames in 4 styles and adding other structural and control elements, a total of 16 styles may be extrapolated. But *how* will this authoring of exemplar frames be accomplished? Some indication will now be given of what the 4 kinds of information in exemplar frames might look like. The topic for these examples is from the field of ergonomics[31]. These examples are not intended to represent how a CAIUS frame would *actually* look or operate. They are intended to convey an *impression* of the kind of material that might be used in each case (an INTUITION viewpoint...)

31 The examples given here concern posture among schoolchildren when engaged in study at desks in the classroom, and stress the importance to good posture of well designed seating. Examples are mainly taken from Lueder & Noro (1994), especially the work of Mandal, pp. 173-178, and pp. 269-277.

5.6.10 SENSING example

The focus of SENSING is a reliance on factual data: verifiable quantitative data; measurements; practical aspects of testing and its outcomes; and authoritative sources for further information. Additionally, historical aspects of the subject may be dealt with. The text deals with the subject by careful explanation. The presentation may have multiple sources of data such as databases, tables, and spreadsheets. Typical SENSING frames might therefore contain the following:

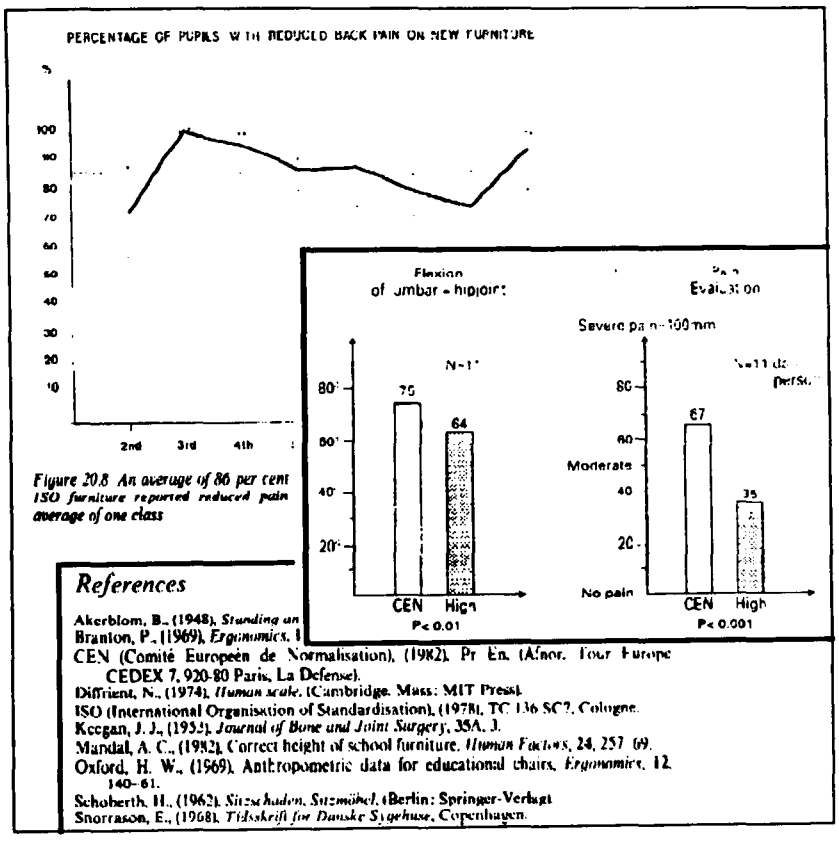

Figure 20.8 An average of 86 per cent ISO furniture reported reduced pain average of one class

Figure 5.27: Example of style for SENSING

5.6.11 INTUITION example

The focus of INTUITION is future possibilities: new ideas and theories are explored. In this instance, new concepts for seat designs which have been tried and which could be further developed, are explained in terms of any underpinning theories relating to natural postures. Additionally, alternative (and perhaps conflicting) viewpoints may be offered. These exemplars may be explained with much imagery, sketches, and impressions, and may border on the fantastical: all imaginings are permissible. Typical INTUITION frames might therefore contain the following:

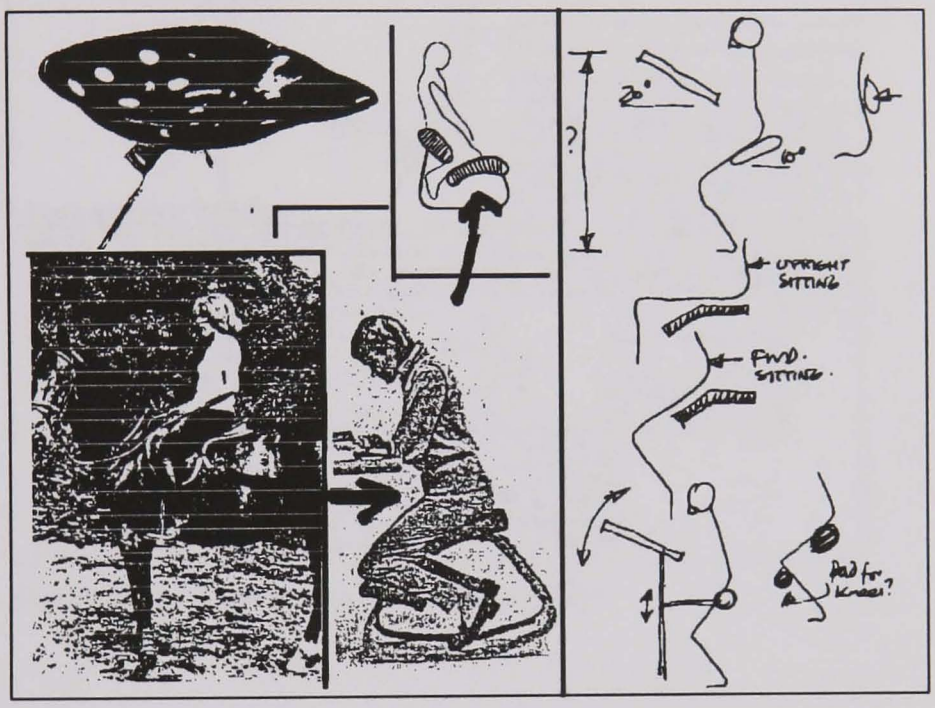

Figure 5.28: Example of style for INTUITION

5.6.12 THINKING example

The focus for THINKING is logical analysis: underlying principles and standards are explained. Anatomical details are given which impact upon posture. Texts are fully referenced, and there is critical appraisal of current advanced work in the field. Attention is given to details. The style is academic and scientific. Additionally, there may be discussion of the objects themselves: analysis of chair structures and their effect upon posture. Performance standards may be listed. Typical THINKING frames might therefore contain the following:

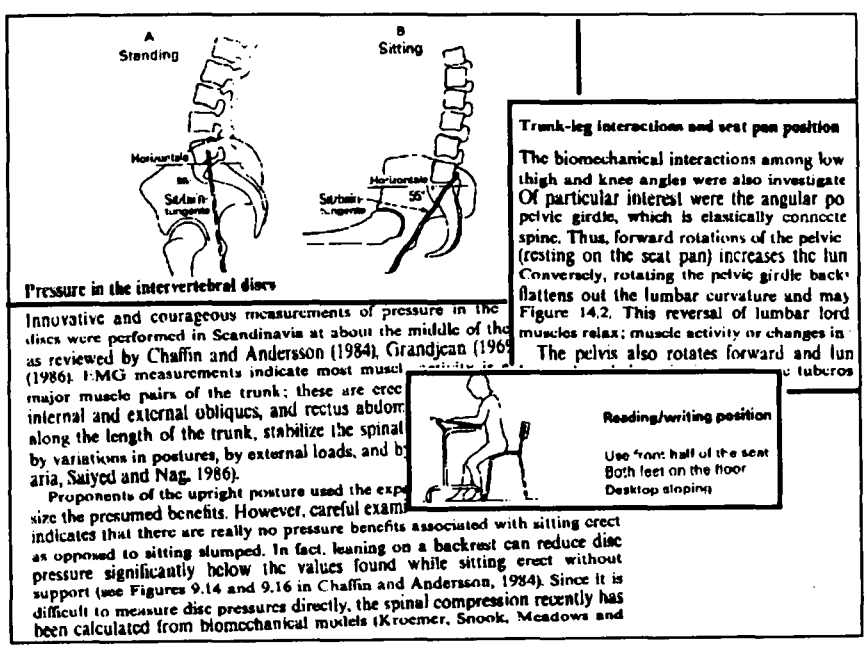

Figure 5.29: Example of style for THINKING

5.6.13 FEELING example

The focus of FEELING lies in value judgments: it is much more interested in the effects of posture on people's well-being. Hence, posture training of schoolchildren is shown not to benefit their posture when typically working at school. Details of spinal problems arising from seating may be coupled with information on illness and work absence due to back related problems. Human preferences in sitting may be dealt with, particularly those in the affective domain. Subjectivity may be entertained, for example vaguer notions such as comfort may be discussed. Additionally, in the absence of hard data, value judgments may be made about good or poor seats. Ways in which technology can help people in their posture or make them more comfortable or efficient may also find a place here. Typical FEELING frames might therefore contain the following:

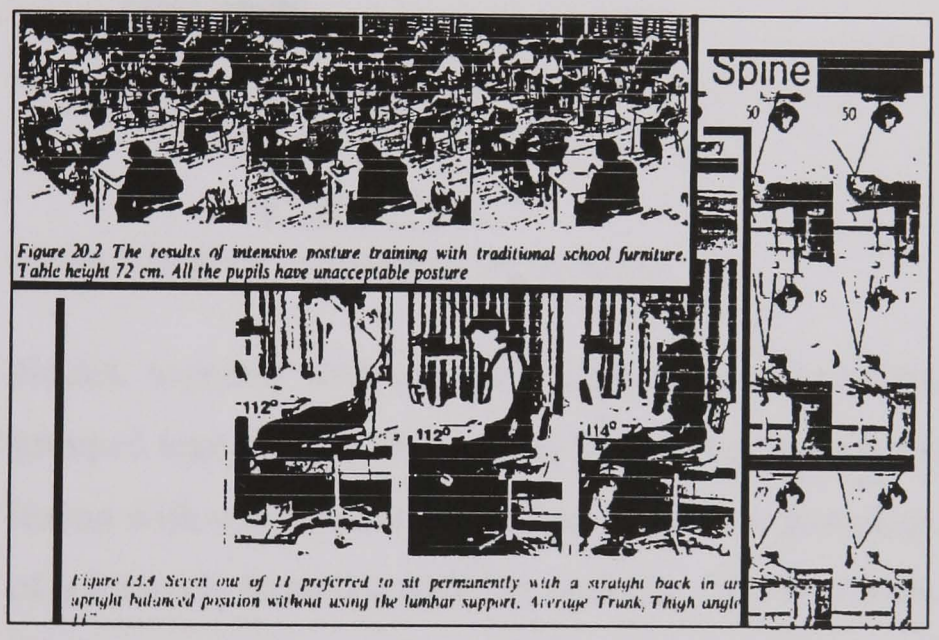

Figure 20.2 The results of intensive posture training with traditional school furniture. Table height 72 cm. All the pupils have unacceptable posture

Figure 13.4 Seven out of 11 preferred to sit permanently with a straight back in an upright balanced position without using the lumbar support. Average Trunk, Thigh angle

Figure 5.30: Example of style for FEELING

5.6.14 Levels of structure

A node has already been defined (cf. 4.5) as a *point* of educational information. In this scheme, it may be conceptualised as a *screen* of teaching material or as the smallest teaching unit in the CAIUS model. For example, a node containing the topic *seat comfort* would have links to various structural elements as appropriate, together with any necessary controls which allow looping back, reviewing previous nodes etc. It might also have links to teaching and information resources related specifically to seat comfort. This is shown schematically in fig. 5.31. Initiative may be taken by the computer system or by the user, depending upon position in the matrix of styles. From the node, information browsers may be accessed and, depending on the style of teaching, goals and mileposts may also be shown[32].

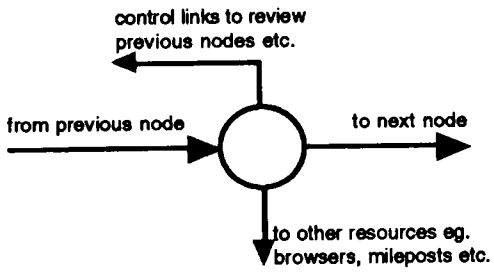

Figure 5.31: Node, and links to other resources.

Nodes, together with their attendant browsers and structural elements, may be grouped together in educationally meaningful sequences to form part of a complete lesson with specific learning objectives. This grouping of nodes as a defined part of a lesson is termed a teaching *episode*. This is shown schematically in fig. 5.32. It therefore follows that a complete lesson will comprise a number of episodes which are themselves arranged in an educationally meaningful sequence. These form the following arrangements

- nodes are the smallest teaching device
- nodes are grouped as a teaching episode
- teaching episodes are grouped as lessons

32 In a fully developed instructional programme, it might be thought desirable to have, periodically, questionnaire tests of learning coupled with appropriate links for the learner to revisit previous nodes or complete lessons either for further practice or for remediation. Additionally, overlaying the programme would be menus or other suitable navigational structures for accessing different parts of the programme. For clarity, the CAIUS model outlined here omits these features.

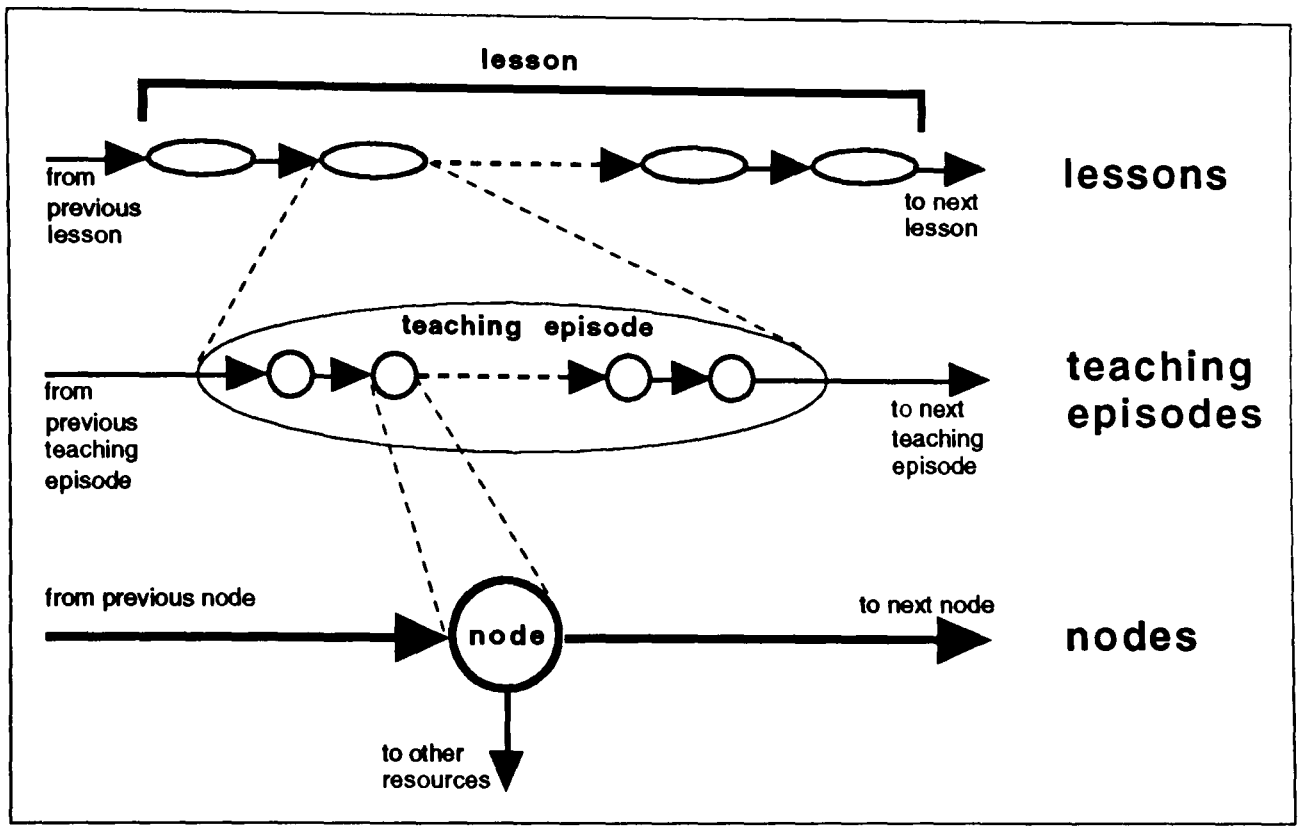

Figure 5.32: Levels - lessons, teaching episodes, and nodes

The CAIUS model outlined here is described in terms of nodes and links, but it is recognised that a full implementation of a lesson will require an overarching supporting structure at the teaching episode level and at the whole lesson level[33].

33 A number of other possibilities (INTUITION viewpoints...) arise from these structures too. The CAI system may be linear and guided at one level but not at another: for example, a lesson may be sequential but be more exploratory within teaching episodes. There is also scope for teaching episodes to share nodes; and for lessons to share episodes. Ultimately, a lesson may form part of a course of instruction in a particular subject.

5.6.15 Rules

Rules for the computer implementation of this model for 16 styles may now be stated formally.

5.6.16 Types

Defines the classification to be used, following the MBTI (cf. 3.2.7).

```
ISTJ, ISFJ, INFJ, INTJ, ISTP, ISFP, INFP, INTP, ESTP, ESFP,
ENFP,ENTP, ESTJ, ESFJ, ENFJ, ENTJ
```

5.6.17 Dominance

This defines, for each of the 16 types, the functions of: dominant; auxiliary; tertiary; and inferior (cf. 3.3.1). This is the order in which exemplar frames are presented.

```
If ISTJ then sequence = S, T, F, N
If ISFJ then sequence = S, F, T, N
If INFJ then sequence = N, F, T, S
If INTJ then sequence = N, T, F, S
If ISTP then sequence = T, S, N, F
If ISFP then sequence = F, S, N, T
If INFP then sequence = F, N, S, T
If INTP then sequence = T, N, S, F
If ESTP then sequence = S, T, F, N
If ESFP then sequence = S, F, T, N
If ENFP then sequence = N, F, T, S
If ENTP then sequence = N, T, F, S
If ESTJ then sequence = T, S, N, F
If ESFJ then sequence = F, S, N, T
If ENFJ then sequence = F, N, S, T
If ENTJ then sequence = T, N, S, F
```

5.6.18 Processes

Shows the treatment for each of the mental processes SENSING•INTUITION and THINKING•FEELING. These mainly denote the treatment of exemplars. S•N specifically defines the direction of learning and linearity.

```
If S then
    Exemplars = Facts [practical, here and now, realistic, details]
    Instruction = Linear [sequence of presentation is mainly fixed]
    Direction = C➔A

If N then
    Exemplars =  Possibilities  [alternatives, futures, imaginings,
    wholes]
    Instruction = Exploratory [sequence of presentation is mainly
    suggested]
    Direction = A➔C

If T then
    Exemplars = Analysis; things [objective, critical appraisal,
    impersonal, thing-centred examples]
    Show Goals

If F then
    Exemplars =  Values; people   [subjective, value judgments,
    beliefs, personalistic, people-centred examples]
```

5.6.19 Attitudes

These are variables based upon 2 forms of ATTITUDES. This represents extra features preferred by certain types, together with the order in which information browsers are presented.

```
If J then
    show goals
    show milepost
    show        1 tree index
                2 hypertext index

If P then
    show        1 hypertext index
                2 tree index
```

5.6.20 Examples of CAIUS

The application of these rules and the CAI specifications will now be demonstrated. As examples, the MBTI type E<u>N</u>TP is contrasted with the type I<u>S</u>TJ. The INTUITION dominant type E<u>N</u>TP represents 27% of designers. The SENSING dominant type I<u>S</u>TJ represents 24% of business managers; and 23% of computer professionals.

5.6.21 Exploratory node

The structure of an E<u>N</u>TP node suitable for designers is as follows.

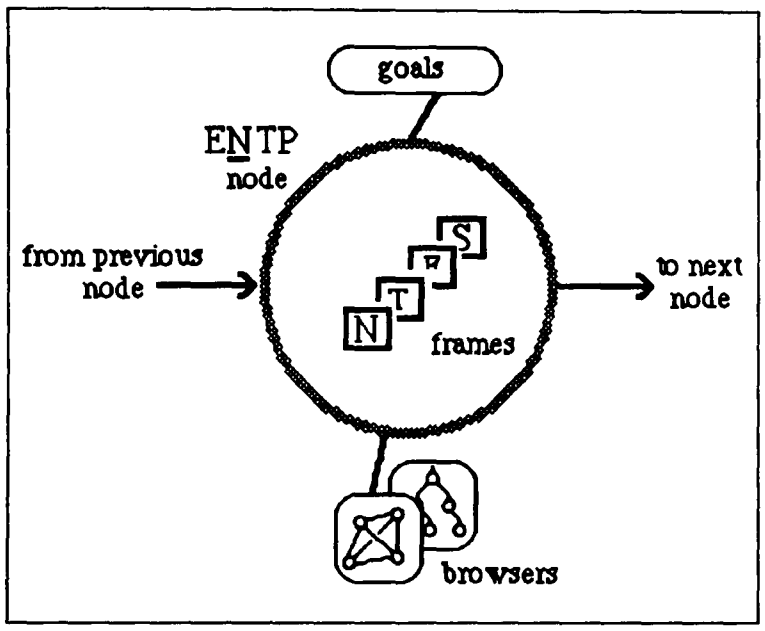

Figure 5.33: Exploratory CAI node suitable for E<u>N</u>TP designers

This example has the following features

- an open, and *exploratory* structure allowing choice
- frames are shown in a *suggested* sequence, but the learner may choose the sequence of viewing
- a *hypertext browser* is suggested firstly
- information on learning goals, are available *if required*

5.6.22 Exploratory screen

Arising from this teaching style, a typical screen for E<u>N</u>TP may be conceptualised as follows.

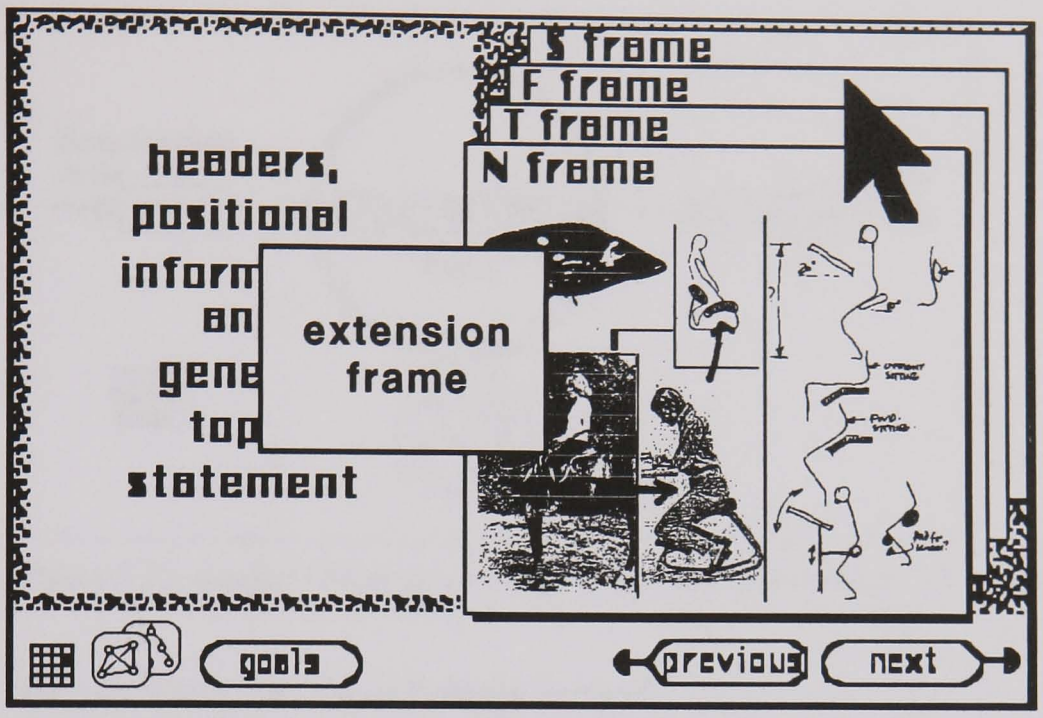

Figure 5.34: Exploratory screen diagram showing frames and controls

To the left of the screen is general information about the topic: this could also display positional data, section titles etc. To the right are 4 exemplar frames displayed in the suggested order of study, though the learner can click on them to view them in any order. Frames may have extension frames which are displayed by clicking on hotspots in the frame[34]. To the bottom of the screen are the various controls appropriate to the style of E<u>N</u>TP ie. browsers, goals, and buttons to navigate to the next node. Moving to the next node will present the next unit of the teaching episode via a similar screen. It is as easy to go back and repeat nodes as required as it is to move forwards in the domain.

34 Extension frames may also have hotspots which link them to further extension frames. In this way a considerable variety and richness of subject matter may be developed.

5.6.23 Guided node

In contrast to the designers' exploratory node, the structure of an ISTJ node is as follows.

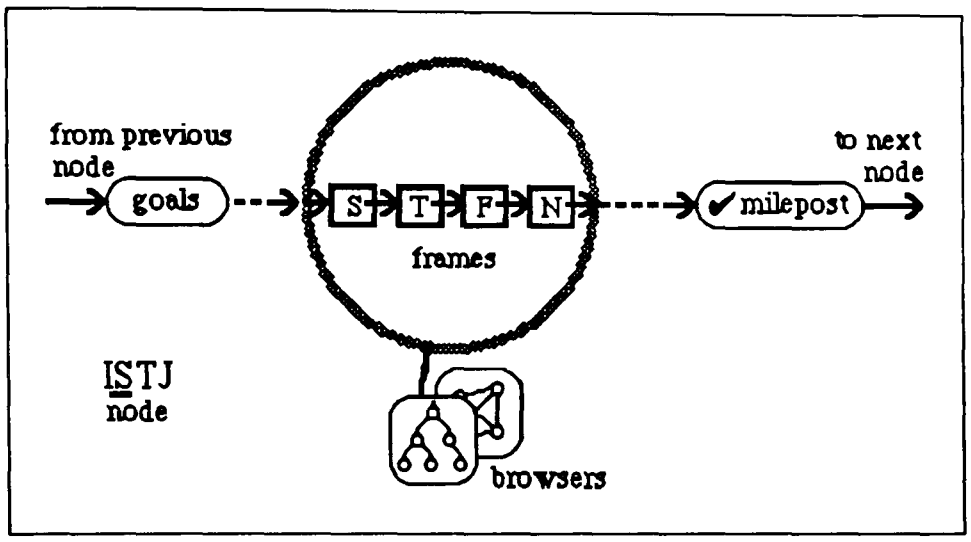

Figure 5.35: Guided CAI node suitable for ISTJ business managers & computer professionals

This example has the following features

- a linear model which offers a more *guided* structure
- frames *must* be viewed in the order in which they are presented
- a *tree* browser is suggested firstly
- learning goals *are* made explicit at the outset
- learning achievements *are* celebrated afterwards

5.6.24 Guided screen

Arising from this teaching style, a typical screen for ISTJ may be conceptualised as follows. The learner is at the position of the first frame of the node.

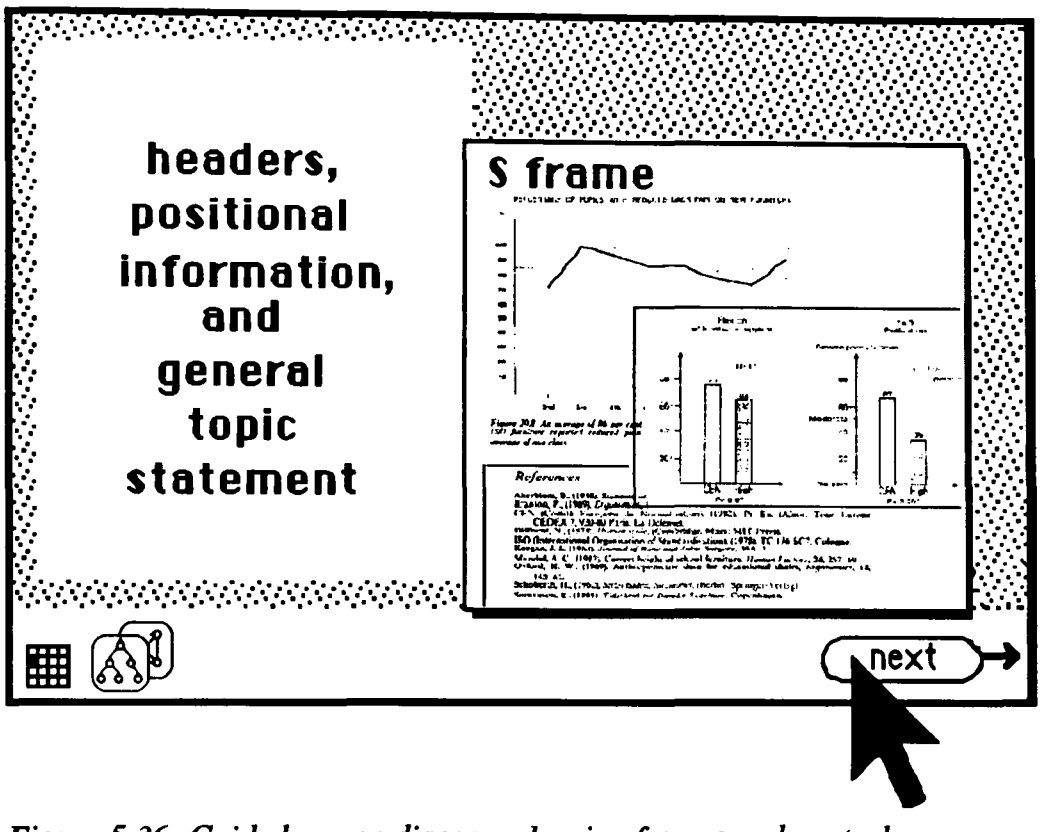

Figure 5.36: Guided screen diagram showing frames and controls

As part of the teaching episode (of which this node forms a part), goals will have been experienced sometime prior to this screen. Similarly, mileposts will be experienced after this node or at the end of the teaching episode. Because there is no choice by the learner over the order in which frames are viewed, only one exemplar frame is shown at a time. The *next* control takes the learner to the following frames (in the order S, T, F & N). Once through this cycle, the following node of the teaching episode will be experienced. The learner is constrained to move forward through the frames until allowed to return and practice etc.

From the learner's viewpoint this represents a quite different experience to the previous example of a more exploratory style of interaction. These two different kinds of learner would therefore derive significantly different experiences from similar educational materials.

5.6.25 Examples of 16 styles

The following diagram shows examples of all 16 CAIUS styles. The 2 previous examples (ENTP and ISTJ) are shown highlighted.

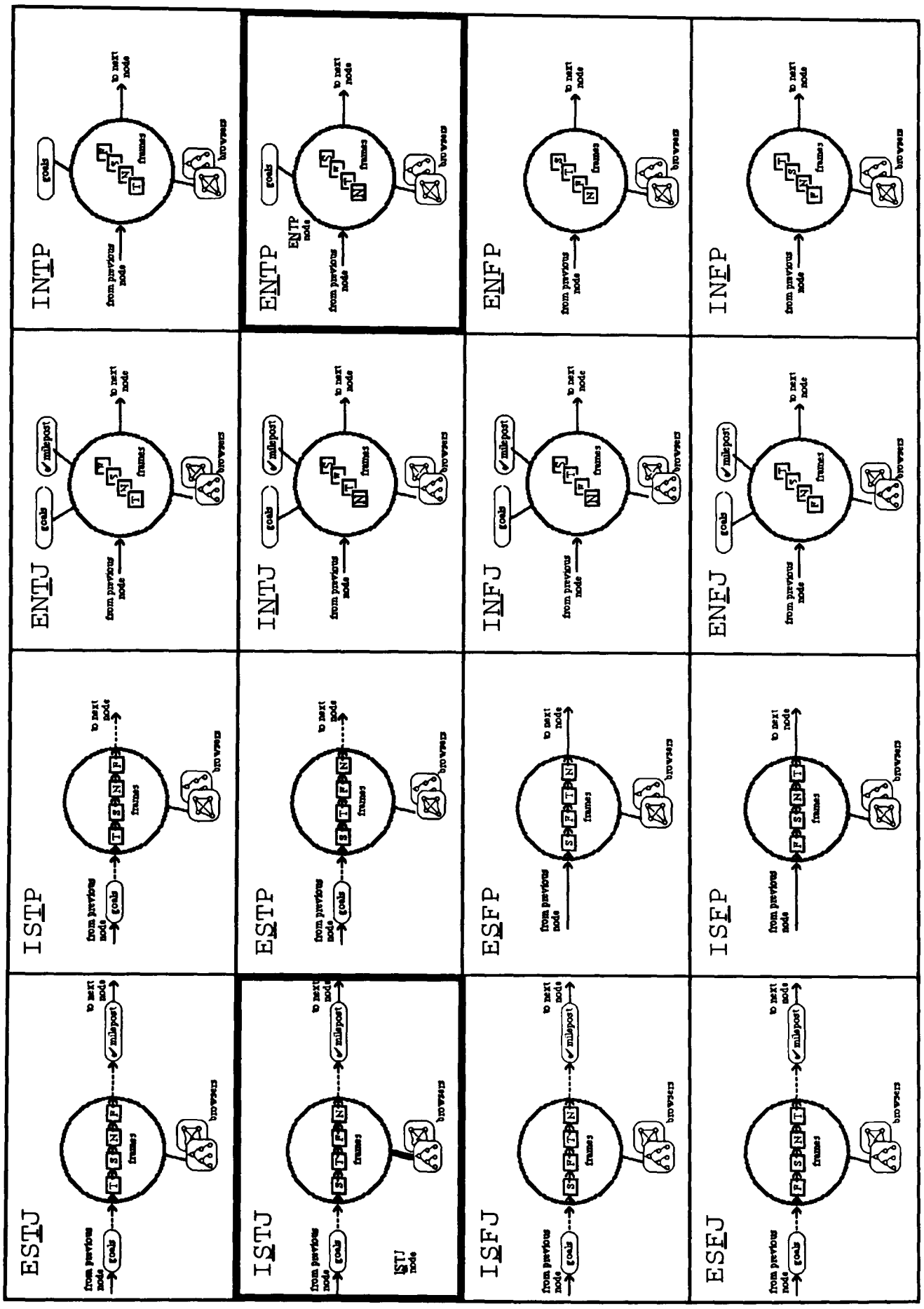

Figure 5.37: CAIUS 16 styles

5.7 Conclusion

The 4 MBTI mental processes, in combination with preferences from other MBTI scales, have been shown to be a suitable way of structuring CAI using learning styles. The CAIUS model which has been detailed takes account of basic learning preferences and provides a skeletal framework for authoring to style. The style selection interface is a simple matrix which may be implemented easily on a computer, and which has the potential to offer users a range of entry modes from computer assessment of their learning style through to direct user choice of style. CAIUS is not intended as a full authoring system: rather, its use is intended at the level of nodes and their supporting structures. Teaching episodes can be envisaged which comprise nodes and links that are clustered in educationally meaningful ways. In a full computer implementation, groups of these episodes will be combined with appropriate control and feedback mechanisms which together will form a complete lesson.

We can see from the CAI specifications that the preferential use of one MBTI dimension can lead to potential learning problems. As an example designers, being strongly INTUITION types, have a reliance on intuiting future possibilities. This may lead them to overlook facts (a SENSING process). It might therefore be educationally sound to teach designers in a predominantly INTUITION way, but to also explicitly support their learning with factual data and more analysis. In the CAIUS model all learners are exposed to the *opposite* of their natural preferences. Learners are exposed to all exemplar frames written in factual, ideational, analytical, and personalistic styles.

Designers' needs in learning are perhaps more sharply defined than many other occupational groups. Their requirement for a light structure, allowing of associations and relationships together with a good deal of exploratory user-centred control, marks them out as being quite unsuited to conventional linear CAI of the drill and practice kind. On the other hand, some types will be more suited to a linear approach, and this may explain why computer based training by, for example

the military and in such areas as banking, has proven effective.

Following the explanation of rules for implementation of the model on a computer, outline CAI models have been demonstrated for two quite different psychological types, and these give an impression of the different ways in which teaching will be experienced: in an exploratory way by typical designers; and, for example, in a more guided way by business managers and computer professionals. The brief examples of exemplar frames in 4 styles shows the differences in the kind of information available. When these styles are mixed with different sequencing (so that information is presented in a different order); different structures (one linear, the other more exploratory); it can be appreciated that the educational experience of one student will be quite different to another.

Chapter 6

End

6 End

6.1 Conclusions

In answer to the research questions raised at the beginning of this thesis (cf. 1.3) the main findings arising from this investigation are as follows.

Are there styles of teaching and learning?

- there are detectable differences between individuals in their styles of teaching and learning
- there are detectable differences between occupational groups in their preferences for teaching and learning, and these have been demonstrated for technology, for business, and for design

Do designers have particular styles of learning?

- designers have particular learning styles. These are similar to — but not the same as — the learning preferences of cognate professionals
- compared to a general population, designers have quite different learning styles

Is there a mismatch between designers and some tutors?

- designers are different in their learning preferences to some other professionals with whom they could be expected to have contact in an educational setting

Does CAI exhibit particular styles?

- CAI has particular styles which arise from the propositional nature of programming and the operation of computers
- much hypermedia has little or no instructional methodology, consisting instead of information held in database structures

Is there a mismatch between CAI and designers?

- there is a mismatch between the learning styles of designers and the kind of CAI which has a linear structure
- design students seem suited to more exploratory kinds of CAI systems

Can styles suitable for designers be implemented on a computer?

- learning style preferences derived from the MBTI can be matched to computer based methods
- an adaptive computer-based theoretical model has been outlined which caters for sixteen styles of learning
- examples have been demonstrated of the possible implementation of such a model in a CAI system

6.1.1 Styles of people

In the context of adult learning, the literature on teaching has demonstrated several cognitive styles together with the various learning strategies employed by individuals. Aspects of designerly thinking are useful in understanding the background to designers' problem solving strategies, creativity, and learning preferences. The knowledge imparted in a teaching situation can be seen as information interpreted by the teacher and filtered through their particular worldview. Cognitive dissonance occurs when there is a mismatch between teacher and learner, and much anecdotal evidence suggests that many students commonly have difficulties with both the form of educational materials and their typical delivery through lectures. Different forms of presentation seem to suit different students. Design education has traditionally been predominantly project-based, often with one-to-one tuition. This style of teaching provides many opportunities for teacher and learner to understand each other in ways not possible with more formal one-to-many instruction.

There is evidence across a wide range of psychological scales of several distinct characteristics of designerly thinking arising from personality or more specific cognitive attributes. There are also indications of small but detectable differences

between designers and cognate professionals. The survey of design students suggests that designers cannot be classified as one type, although they are strongly clustered in half of the MBTI typology. It would be wrong to believe that designers can be taught in only one way: at the level of individuals they are represented in most parts of the matrix. But as a group designers are generally shown to be quite different types to some other professional groups with whom they might naturally come into contact in an educational setting, perhaps especially those teachers who come from technology or business studies.

6.1.2 Styles of CAI

The historical context of computer aided instruction in its various forms suggests that hypermedia guidelines often ignore important pedagogic issues such as instructional models and styles of delivery. Too often, hypermedia self-learning applications are either rigid programmed learning, or are little more than databases where the learner finds information by browsing. It has been conjectured that the styles of authoring or of programming languages lead to particular styles of human-computer interaction. These may not match all learners' preferences. Although the potential for using psychological attributes, including personality, are often mentioned in the HCI literature, guidance usually stops short of practical ways of implementing such concepts. Media are shown to have various levels of credibility, and the tone of information has to be right for the target user.

6.1.3 Styles of designers

A personality inventory was preferred to a learning style model. The MBTI has been chosen as a robust psychometric instrument which is suitable for the sorting of individual learners into types of personality. Data from occupational groups show significant differences between groups which both differentiates designers from some others and also demonstrates similarities to cognate disciplines such as architects. As a group, designers are shown to be strong in certain characteristics such as INTUITION and PERCEPTION. However, designers are not all of one kind: there is considerable variety, and there are subtle differences between various kinds of designer.

Arising from these cognitive differences, lecturers may teach within a style which represents the limits of their personal worldview. Conversely, computers support styles arising from their programming, different kinds of media, and any authoring systems used in hypermedia development. As there may be a mismatch between human tutor and learner under some circumstances, it follows that there may be a similar mismatch between computer and learner where the style of CAI is dissonant with the particular style of the learner.

6.1.4 The CAIUS model

A major part of this research has been an attempt to rigorously map learning styles to computer styles. This has been achieved through the MBTI scales, which are associated with specific preferences for learning. These preferences cover the focus of presentation, the kind of material, the type of instruction, and whether control is exercised more by the computer system or by the user. Two instructional directions cater for learners who prefer facts first or concepts first. A reworked MBTI typology is detailed which has several useful elements that form the basis of the interface. This model can cater for up to 16 possible styles of teaching and learning. Several methods for entry to the system are proposed. Naive users may be assessed by a simple questionnaire. Experienced users may go straight to their preferred style of interaction. Finally, a simple demonstration of 4 exemplar frames from a hypothetical ergonomics lesson is shown in order to give some impression of the different kinds of educational experiences which could be provided through application of the CAIUS model.

6.2 Research contributions

There are several contributions which this thesis makes to the field of design education through computer aided instruction. These are predominantly in the classification of designer personality using the MBTI, and its implementation in a model of human-computer interaction for educational purposes. The major contributions are discussed as follows.

6.2.1 Designer personality

There are personality and related learning style differences which can be detected between designers and other occupational groups. The data (both from the CAPT *Atlas* and from my own survey) show designers to markedly prefer INTUITION and also to have a strong preference for a PERCEPTION attitude. Designers are quite different to a general population. The survey of typical UK design students is the first study of its kind, though designers have been similarly assessed in the USA and elsewhere. The results show marked consistency with previous studies of cognate professionals, for example architects and interior designers. Descriptors for the types represented by most designers, and for the MBTI scales which are a component of that type, show correspondence with descriptions of designers' cognition, and with their own descriptions about the way they work. This is especially true of the *intuitiveness* which they describe, and which they have difficulty expressing in words. One contribution to design education is therefore in drawing attention to the use of a robust psychological framework which facilitates describing these behaviours, and assists in better understanding their nature. Arising from this is the proposition that teaching should be in a style appropriate to the learner.

6.2.2 CAI using styles

The specific use of the MBTI as a framework for understanding designer personality (and its associated learning styles) is a new departure for UK design education. The instrument is robust and has generated a considerable literature together with a large corpus of occupational results. It offers a way of assessing individual designers and suggesting appropriate treatments for instruction based on their preferences for learning. The idea of psychological types being considered in the development of an adaptive interface is not new, but it is believed to be the first time this possibility has been studied in detail. No other CAI model is known which features a model of personality as its basis.

However, the MBTI does not directly provide preferences for learning. These must be derived from the literature on psychological types. In contrast to the elegant

simplicity of the structure from which the Jungian types emerge, the literature on related learning styles (and other characteristics useful in the context of design education) is more vague and is sometimes poorly referenced. This study has attempted to chart related learning styles by systematically summarising from a variety of sources and observations, and has assembled them into a coherent framework. Instead of attempting to associate learning styles individually with each of the 16 types, the strategy has been to utilise the 4 scales as a framework which can be implemented on a computer.

The types have been repositioned within a matrix revised along lines of preference. This is a more suitable typology for design education and offers distinct advantages for the computer-implementation of learning styles. The CAIUS model operates at the lowest level in four basic styles, and is capable of handling up to 16 styles. The quadrants are consistent with the separation of the main occupational groups discussed. By moving orthogonally, learners are progressively guided towards alternative teaching styles. The user would be able to choose an appropriate style either alone or under computer guidance. Authoring will be undertaken in only 4 basic styles (together with some guidance materials such as *mileposts*) and it is not difficult to conceptualise how the system could prompt an author in the different modes.

6.2.3 Teaching and learning

It has been shown that cognitive dissonance between teacher and learner may occur. In a group of students, individuals will not benefit equally from a particular way of teaching. Due to their distinctive preferences, designers are in a minority. Teachers from other subjects such as engineering, business studies, or computing, are likely to teach designers in ways that are alien to them. Under these circumstances, cognitive dissonance may be experienced and, as a consequence, understanding of the subject may be diminished. Traditional forms of programmed learning offer rigid instruction and little user choice. These seem to be quite unsuitable for most design learners.

6.2.4 Foundations of further work

This research provides a basis for continuing investigations into suitable hypermedia interfaces for designers and others in an educational context. It also raises some interesting possibilities for future research into personality related aspects of designerly thinking and links with creativity and problem solving. Another field of considerable importance is the likely mismatch in communications between designers and other professional groups.

6.3 Limitations of this research

There are several areas of limitations to this study ranging across detailed approaches to implementing instructional models, and further development of, and additions to, the CAIUS model.

6.3.1 Sample sizes

The overall sample size of design students at UK universities is, like some of the CAPT samples, on the small side. The results should therefore be verified by a larger sample of design students. This might also have the benefit of providing data on possible differences between various kinds of designer. For example, it has been conjectured that design/marketing students might prefer more SENSING and more JUDGMENT than the other design students tested. It might turn out that, for example, fashion students prefer more INTUITION and more FEELING, or that designer/craft workers prefer more SENSING. Reliable data would assist the formation of appropriate strategies for the matching of teaching and learning for these and other groups.

6.3.2 Correlations

There is a considerable corpus of knowledge about correlations between other psychometric scales and the MBTI. These have been drawn together in a coherent way for learning styles. It is expected that further study of correlational data will not only consolidate the CAIUS model, but will add further detail. For example, reports of positive correlations between MBTI scales and preferred kinds of media are sketchy, and there is little information presently reported on dislikes for specific

media. Due to this vagueness, media have not been incorporated into the CAIUS model, but this is a future priority. Interestingly, positive correlations seem particularly strong between other instruments and the MBTI scale of INTUITION. Some of the traits reported concern *aestheticism*, *openness*, and *creativity*. A large majority of the designers tested had the preference of INTUITION.

6.3.3 Instructional models

There are two instructional directions incorporated into the CAIUS model. For SENSING types the instructional model progresses from concrete to abstract. For INTUITION types the instructional model progresses from abstract to concrete. These only indicate what could be a wider and more detailed educational model or models. Studies have been reported which touch on this in the context of the MBTI, and there are various suggestions for the incorporation of instructional theories which may offer varying treatments to suit different kinds of learners.

6.3.4 JUDGMENT • PERCEPTION

Although the literature is clear about JUDGMENT requiring more structure and need for closure than PERCEPTION, an assumption has been made that a preference for JUDGMENT is synonymous with a preference for more structure. This assumption, while rooted to some extent in the inherent structure of the scales, influences progressive control by the user in the horizontal direction of the matrix, and requires further research.

6.3.5 EXTRAVERSION • INTROVERSION

It has been shown that CAI may be more suitable for those learners preferring INTROVERSION than EXTRAVERSION. The descriptors for INTROVERSION point to a liking for self study; a need for privacy; quiet reflection; and sustained concentration. Although the use of EXTRAVERSION is important in establishing dominance of the mental processes (and therefore the ordering of exemplars) there is little learning style contribution from EXTRAVERSION embedded in the model. This is disappointing. More was not attempted due to a lack of hard evidence. EXTRAVERSION should lend more of a relation to the outer world, best seen in action

in the outer world, and a need for people and group working. A more EXTRAVERSION version of CAIUS would perhaps try to create something of what it is like to deal with people, and to think out loud, verbalising concepts etc. However, this seems to run counter to working alone with a computer. One suggestion is that computer teaching be coupled with external projects employing teamwork. An alternative might be computer supported collaborative working (CSCW) where people work together on a project through the mediation of computer technology. It might also be possible to associate specific media (dis)likes with EXTRAVERSION. For example, it might turn out that video has greater significance, so more lessons could be offered in this form. Lastly, and perhaps more distantly, it might be that EXTRAVERSION will find its match in fully immersive virtual reality systems offering more potential for direct action in the outer world, albeit a virtual one.

6.3.6 Other combinations

It is implicit in the CAIUS model that other combinations of style are possible. For example, an INTUITION learner (A→C) might prefer a SENSING instructional model (C→A) for some of the time. As this would not be consistent with Jungian theory it has not been supported here. It is however interesting to speculate that combinatorially many more kinds of instruction might be made available to learners.

6.3.7 Empirical testing

CAIUS has not been empirically tested. The study has been aimed at providing a theoretical basis for the development of such a model. One obvious further line of enquiry lies with the design, development, and empirical evaluation of a full hypermedia implementation.

6.4 Future research

Beyond the immediate focus of this thesis, there are several areas where the concepts which have been introduced may be investigated further and developed. For example, a larger study of designers' personality has been mentioned. This

could provide reliable data and consolidate the preliminary work reported here. More reliable and detailed data on designer personality may also lead to a surer understanding of the roots of creativity, and may inform the teaching of aspects of creativity. At a general level, the MBTI itself might find more use in counselling in design education: this could help students understand the nature of their own creativity and their particular learning needs. In having a greater understanding of learning, students may be better equipped to adopt appropriate learning strategies for various tasks, particularly in relation to self-directed learning and continuous professional development.

The processes SENSING • INTUITION and THINKING • FEELING show 4 distinctly different viewpoints on the collection of information and making decisions about that information. In problem solving, it may be useful to expose students to the shadow side of their natural mental processes in order to see problems from other, less natural, perspectives. The CAIUS model could provide a starting point for a computer based tool that will augment human efforts toward creativity. In this respect it offers a tentative model for a fourfold approach to problem solving behaviours which might be further investigated.

6.4.1 Interactivity

Although the term *interactivity* is widely used in hypermedia authoring (perhaps especially by authors and designers), the nature of human-computer interaction is still poorly understood in terms of cognitive styles. This thesis takes us some way towards understanding learning style components of interactivity. In conjunction with other HCI guidance it may be seen as playing a part in attempts to understand the *psychological engineering*[1] of educational interfaces.

As computers become ubiquitous and transparent by being absorbed within everyday products, the notion of achieving a better fit between human cognitive characteristics and smart machines will become ever more important. There is

1 A term used by Thimbleby (1990) to emphasise that user interface design is about the complete human-computer system, and which involves the development of formal methods in order to program equally for the needs of both the machine and the user.

reason to suppose that the video cassette recorder could be made adaptable to its user's requirements for control of playback, for programming, and for setting the time: it might even suggest the kinds of material to be recorded, based on the interests of its users. With the convergence of several media types into what is being termed the *interactive TV*, achieving better human-computer communications will be a priority. The same thinking might be applied to the washing machine; the freezer; and fax and answering machines, among many other possibilities.

6.4.2 Media

CAIUS requires more work in determining specific additions to the learning styles. There is insufficient evidence of preferences for media types. For example, it can be gleaned from the literature that some types (such as SENSING+THINKING) like video presentations and that they may benefit from having the opportunity to repeat these lessons. We also know that INTUITION dominant types are more bookish. But beyond this, evidence needs to be assembled for further preferences for media. This may prove especially important to promote the credibility of media for design professionals, and their acceptance of it.

6.4.3 Authoring

The CAIUS approach could have a significant impact as a structure for authoring. Some interesting work is envisaged in devising an authoring tool or template which prompted for the input of information in the 4 basic styles, and also prompted for the necessary inputs for structural elements such as goals and mileposts.

6.4.4 (Dis)likes

In a more general vein, there are several aspects which may inform the education of both designers and others. It is clear that individual learning styles influence the degree of comfort a learner will feel with the instruction offered. This affects both the tone of information and, perhaps more crucially, the order of presentation. In CAIUS, all the kinds of exemplar are shown to all learners: only the order of presentation is changed. There is some evidence that some learners are more

intolerant of their minor preferences than are some others. One example may be an apparently strong dislike by FEELING types of topics which they regard as dry and boring. While it can be argued that it is educationally sound to expose a student to those domains which they would not naturally address, over-exposure to unpalatable material may be counter productive. More work needs to be done on defining these specific dislikes and adopting methods to address them, perhaps by limiting the learner's exposure to some of the least preferred frames. This could offer a rational basis for moving forward in refining specific preferences and relating these to suitable teaching structures.

6.4.5 Communications between professions

If the teaching of, for example, ergonomics to designers can be better matched by the CAIUS model, it follows that the converse is true: that is, shaped in the correct way design might be better communicated to ergonomists in ways that will suit *their* special ways of understanding. The same reasoning can be applied to the sometimes difficult communications between the worlds of design and manufacturing businesses. A significant part of the designer's professional role is to maintain good relations with her/his clients. It may prove useful to teach design students about understanding the nature of their worldviews relative to non-designers in order that they can communicate more effectively. The CAIUS model provides a structure for understanding these disjunctions and applying treatments to promote better communications.

6.4.6 Learner assessment

The basis of the MBTI framework is that people are classified as being either at one end or the other of a dichotomised scale. One is pigeonholed as eg. SENSING or as INTUITION. There is nothing in between, though it is recognised that these are natural preferences and individuals usually exhibit scores somewhere between the two extremes. At the moment the CAIUS model assumes type categorisation: there are 16 classified types, therefore there are 16 instructional treatments. One possible refinement could be to utilise the preference scores shown for each dichotomised scale to provide a weighting for that preference. It may be, for

example, that although a certain type has a preference for specific media, some individuals will prefer more of that kind of media and therefore this might be emphasised by the control system. Alternatively, some individuals may show more dislike for certain kinds of media, in which case the system might be able to reduce their exposure.

Another kind of dichotomy concerns the extent and nature of user initiative versus system initiative, especially with weaker learners. Apart from direct questioning of the student (through a type questionnaire) it is envisaged that CAIUS could monitor the paths that learners use and suggest suitable treatments, either at a coarse level of granularity (4 styles) or at a finer level (16 styles). A more *blue sky* approach to learner assessment lies in having *continuous* computer assessment for style related preferences, and to adjust initiative accordingly.

6.4.7 Design education

Having noted the kinds of persons that constitute the broad body of designers, and having explored some aspects of design education, a further question centres around whether the two are matched? Project-based teaching would seem to have many of the ingredients necessary to suit the exploratory, free ranging nature of most design students. This form of teaching has the great advantage of allowing opportunities for the student to ask appropriate questions or to engage in activities which will assist them in gaining understanding of their subject. Therefore design education seems to be well matched to its students. The dangers in this form of teaching are, however, that design knowledge has not been made as explicit as in some other disciplines, for example in engineering. It is easier for design knowledge to reside in teachers, and this makes it less accessible to a wider audience, less exposed to critical analysis, and more difficult to arrange in a form suitable for teaching through computers.

6.5 Summary of main contributions

The main contributions of this thesis can therefore be finally summarised as follows

- the use of a modified MBTI matrix as a framework for classifying and understanding designer personality

- personality data related to UK design students are reported for the first time

- designer group personality is defined and is shown to be different both in respect to a general population and to other professions which influence design education

- it is shown that teaching by professionals from technology and business studies is likely to be mismatched with the learning styles of designers

- the CAIUS model is a mapping of associated learning styles into a framework progressively offering several preferential pathways under user control or computer guidance

- this thesis also provides a basis for continuing research into hypermedia interfaces employing personality

Additionally, interesting possibilities are raised for research into personality related aspects of creativity, communications between designers and others, and informing design education.

References

References

Allport, G.W., Vernon, P.E. & Lindzey, G. (1960) Study of values: A scale for measuring the dominant interests in personality (3rd ed.). Houghton Mifflin, Boston.

Apple Computer. (1992) Macintosh Human Interface Guidelines. Addison-Wesley, UK.

Arnheim, R. (1970) Visual thinking. Faber & Faber, UK.

Aspillaga, M. (1991) Implications of Screen Design upon Learning. In: Journal of Educational Technology Systems; Vol. 20, No. 1, pp.53-58, 1991-1992.

Baecker, R.M. & Buxton, W.A.S. (Eds.) (1987) Readings in human-computer interaction: A multi-disciplinary approach. Morgan-Kaufmann Publishers, Palo Alto, CA.

Barker, P. (1991) Editorial. In: ETTI, Vol.28, No.4, pp.269-271.

Barker, P.G. & Manji, K.A. (1988) New Books for Old. In: Programmed Learning and Educational Technology, Vol.25, No.4, pp.310-313.

Barron, F. (1965) The psychology of creativity. In: New directions in psychology, Vol. II, pp.1-134. Holt Rinehart, New York.

Benest, I.D. (1990) A hypertext system with controlled hype. In: McAleese, R. & Green, C. (Eds.) Hypertext: state of the Art, Intellect, Oxford.

Bogen, J. (1969) The other side of the brain II: An appositional mind. In: Bulletin of the Los Angeles Neurological Society, Vol.34, No.3, 1969, pp.135-162.

Bogen, J. (1977) Some educational implications of hemispheric specialization. In: Wittrock, M. C. [Ed.] The Human Brain, Prentice Hall.

Bonham, A. (1988) Learning style instruments: Let the buyer beware. In: Lifelong Learning, Vol.11, No.6, pp.12-16, Apr. 1988.

Brown, P.J. (1987) Turning ideas into products: the Guide system. In: Proceedings of Hypertext '87, pp.33-40, Chapel Hill, University of North Carolina.

Bruner, J.S. (1962) The conditions of creativity. In: H. Gruber et al. (Eds.) Contemporary approaches to creative thinking. Atherton, pp.1-30.

Buros (1989) Buros Mental Measurements Yearbook. Buros Institute of Mental Measurements, University of Nebraska Press. (10th Ed.)

Bush, V. (1945) As we may think. In: Atlantic Monthly. 176/1, July, pp.101-108.

Carlson, R. & Levy, N. (1973) Studies in Jungian typology: I. Memory, social perception and social action. In: Journal of Personality, Vol. 41, No. 4, pp.559-576.

Cattell, R.B. & Butcher, H.J. (1968) Creativity and personality. In: Cattell, R.B. & Butcher, H.J. (1968) The prediction of achievement and creativity, Bobbs-Merrill. (Reprinted) Vernon, P. E. (ed.) (1970) Creativity, pp.313-326, Penguin.

Cattell, R.B., Eber, H.W. & Tatsuoka, M.M. (1970) Handbook for the Sixteen Personality Factor Questionnaire (16PF). Institute for Personality and Ability Testing, Champaign, IL.

Clarke, J.A. (1993) Cognitive style and Computer-Assisted Learning: problems and a possible solution. In: Association for Learning Technology Journal, Vol.1, No.1, pp.47-59.

CNAA (1992) Technological change and industrial design education. Council for National Academic Awards, London.

Conklin, J. (1987) Hypertext: An introduction and survey. In: Computer, September, pp.17-41.

Conner, M. et al. (1995) Learning: the critical technology. A whitepaper on adult education in the information age. Wave Technologies International, St. Louis, Missouri . Doc. No. 953-1.

Cooper, L. (1982) Strategies for visual comparison and representation: Individual differences. In: Sternberg, R (Ed.) Advances in the psychology of human intelligence, Vol. 1.

Cropley, A.J. (1967) S-R Psychology and Cognitive Psychology. In: (Reprinted) Vernon, P. E. (Ed.) (1970) Creativity, pp.116-125, Penguin.

Cross, N. (1982) Designerly ways of knowing. In: Design Studies, Vol. 3, No. 4, pp.221-227.

Cross, N. (1985) Styles of learning, designing and computing. In: Design Studies, Vol. 6, No. 3.

Cross, N. (1990) The nature and nurture of design ability. In: Design Studies Vol. 11, No. 3.

Davies, R. & Talbot, R. (1987) Experiencing ideas; identity, insight and the imago. In: Design Studies, Vol.8, No.1, pp.17-25.

Davis, H., Hall, W. & Hutchings, G. (1994) The microcosm appproach to producing computer supported learning materials. Microcosm course notes, held at University of Leeds, 16 June 1994.

De Bello, T. (1990) Comparison of eleven major learning styles models: variables, appropriate populations, validity of instrumentation, and the research behind them. In: Reading, writing, and learning disabilities, Vol. 6, pp.203-222.

Diehl, J.L. (1992) The relationship between creativity, imagery, and personality types in interior design students. Oklahoma State University. Dissertations abstracts international, 93-21561.

Donnelly, P.J. (Ed.) (1994) Constructing and implementing multimedia teaching packages. University of Glasgow. TLTP/TILT.

Downton, A. (Ed.) (1991) Engineering the human-computer interface. McGraw-Hill, UK.

Drucker, P. (1969) Management's new role. In: Harv. Bus. Rev., No. 47, pp.49-54.

Dunn, R. & Cavanaugh, D. (1982) Hemispheric preference: the newest element of learning style. In: The American Biology Teacher, Vol.44, No.5, pp.291-294.

Durling, D. (1994) Hyping style: approaches to design. In: Interact, Vol. 1, No. 4, pp.19-21. <http://valley.interact.nl/av/org/interact/supindex.html>

Durling, D. (1995) Virtual personalities. In: Proceedings of conference 4D Dynamics, September, De Montfort University, UK.

Eberts, R.E. & Brock, J.F. (1988) Computer-based instruction. In: Helander, M. (Ed.) (1988) Handbook of human-computer interaction. Elsevier Science Publishers, Amsterdam.

Edwards, A.L. (1954) Manual for the EPSS. The Psychological Corporation, New York.

Edwards, B. (1979) Drawing on the right side of the brain. Tarcher, Los Angeles, USA.

Eggins, J.A. (1979) The interaction between structure in learning materials and the personality type of learning. Unpublished doctoral dissertation, Indiana University.

Eisner, E.W. (1985) The arts, human development, and education. McCutchan, Berkeley CA.

Ellis, S., Kaiser, M. & Grunwald, A. (Eds.) (1993) Pictorial communication in virtual and real environments. Taylor and Francis, London. (2nd Edition).

Engelbart, D. (1963) A conceptual framework for the augmentation of man's intellect. In: Howerton & Weeks (Eds.) Vistas in Information Handling, Vol 1. Spartan Books, Washington DC.

Entwhistle, N.J. (1981) Styles of learning and teaching: an integrated outline of educational psychology. John Wiley, Chichester.

Faiola, T. & DeBloois, M. (1988) Designing a Visual Factor-Based Screen Display Interface: The New Role of the Graphic Technologist. In: Educational Technology, Vol. 28, No. 8, pp.12-21, August.

Festinger, L. (1957) A theory of cognitive dissonance. (Reissued by Stanford University Press in 1962).

Flynn, J. (1987) Massive IQ gains in 14 nations: What IQ tests really measure. In: Psychological Bulletin, Vol.107, pp.171-191.

Fountain, A., Hall, W., Heath, I. & Davies, H. (1991) Microcosm: an open model with dynamic linking. In: Rizk, A., Strietz, N. & Andre, J. (Eds.) Hypertext: Concepts, Systems and Applications. Proceedings of the European Conference on Hypertext. INRIA, France 1991. 298-311.

Freedman, R. & Stumpf, S. (1980) Learning style theory: less than meets the eye. In: Academy of Management Review, Vol. 5, No. 3, pp.445-447.

Fryer, M. (1989) Teachers' view on creativity. PhD, CNAA, Leeds Polytechnic.

Fuller, R. (1994) Human-computer-human interaction: how computers affect interpersonal communication. In: The Arachnet Electronic Journal on Virtual Culture, Vol. 2, No. 2. Archived as FULLER V2N2 at ftp byrd.mu.wvnet.edu

Gardner, H. (1982) Art, mind and brain: A cognitive approach to creativity. Basic Books, New York.

Gardner, H. (1993) Frames of Mind: the theory of multiple intelligences. Orig. pub. 1983 Heineman, reprinted 1993 Fontana.

Gardner, H. (1995) Creativity: new views from psychology and education. In: RSA Journal, No. 5459, May, pp.33-42. Royal Society of Arts, London.

Gassée, J. L. (1987) The third apple. Harcourt Brace Jovanovich, Florida.

Gibson, W. (1986) Neuromancer. Grafton, London.

Golanty-Koel, R. (1977) The relationship of psychological types and mass media preferences to the values of non-academic high school students. Doctoral dissertation, University of California. Dissertations Abstracts International, 1978, 38, 4683A.

Goldsmith, R. & Blackman, S. (1978) Cognitive style: Five approaches and relevant research. Wiley, New York.

Goodman, D. (1993) The Complete HyperCard 2.2 Handbook. (4th Ed.) Random House Electronic Publishing, New York.

Gorham, J. (1986) ERIC Report: Assessment, Classification and Implications of Learning Styles in Instructional Interactions. In: Communication Education, Vol. 35, No. 4, pp.411-417, Oct.

Gough, H.G. (1975) Manual for the California Psychological Inventory. Consulting Psychologists Press, Palo Alto, CA.

Gregorc, A. (1982) An Adult's Guide to Style. Gregorc Associates Inc., P.O. Box 351, Columbia, CT, USA 06237-9975

Griesen, J.V. (1971) Independent study versus group administration in medical education. Doctoral dissertation, Ohio State University. Dissertations Abstracts International, 1972, 32, 6100A.

Guilford, J.P. (1950) Creativity. In: Amer. Psychol., Vol. 5, pp.444-454.

Halasz, F.G., Moran, T.P. & Trigg, R.H. (1987) NoteCards in a nutshell. In: Proceedings of the ACM CHI+GI Conference, Toronto, pp.45-52.

Harrison, D.F. (1984) The temporal dimension of Jung's psychological typology: Testing an instructional theory of future studies with middle school students. Doctoral dissertation, University of Florida.

Heist, P.A., McConnell, T.R., Webster, H. & Yonge, G.D. (1963) Omnibus Personality Inventory. The Psychological Corporation, New York.

Hoffman, J.L., Waters, K. & Berry, M. (1981) Personality types and computer assisted instruction in a self-paced technical training environment. In: Research in psychological type, Vol. 3, pp.81-85.

Hofstadter, D.R. (1980) Gödel, Escher, Bach: An eternal golden braid. Penguin.

Huckbody, K. (1990) An introduction to computer assisted learning (CAL). University of Bradford, May 1990.

Hudson, L. (1966) The Question of Creativity. In: (Reprinted) Vernon, P. E. (Ed.) (1970) Creativity, pp. 217-234, Penguin.

Hudson, L. (1968) Frames of mind: Ability, perception and self-perception in the arts and sciences. Methuen, London.

Hueser, K. (1991) A comparison of near and far transfer measures using HyperCard presentations matched and mismatched to learning styles. PhD thesis, Kansas State University, Manhattan, KS, USA. On microfiche with Dissertations Abstracts International.

Hughes, K. (1994) Entering the world-wide web: a guide to cyberspace. Enterprise Integration Technologies, Palo Alto.

Jensen, G.H. & DiTiberio, J.K. (1984) Personality and individual writing processes. In: College Composition and Communication, Vol. 35, pp.285-300.

Johnson, J. (1989) Computer-aided learning for computer-aided design: the CADPAC package. In: The CTISS File, number 8, April 1989.

Jonassen, D. (1981) Personality and cognitive style, predictors of teaching style preferences: An exploratory study. In: Paper presented at the annual meeting of the Association for Educational Communications and Technology, Philadelphia PA., April 6-10, 1981, pp.242-285, ERIC Document Services No. ED 207 500.

Jonassen, D. (1985) Interactive lesson design: A taxonomy. In: Educational technology, Vol. 25, pp.7-17.

Jonassen, D. (1988) Designing structured hypertext and structuring access to hypertext. In: Educational Technology, Vol. 28, pp.13-16.

Jonassen, D. (1989) Hypertext/Hypermedia. Educational Technology, Englewood Cliffs, NJ.

Josephs, A.P. & Smithers, A.G. (1975) Personality characteristics of syllabus-bound and syllabus-free sixth-formers. In: British journal of educational psychology, Vol. 45, pp.29-38.

Jung, C.G. (1921) Psychological Types. (H.G. Baynes, Trans. revised 1971 by R.F.C. Hull). Volume 6 of The Collected Works of C.G. Jung. Princeton, NJ: Princeton University Press. (Original work published in 1921).

Jung, C.G. (1954) The development of personality type. Princeton University Press, NJ.

Keefe, J. (1982) Assessing student learning styles: An overview. In: Student learning styles and brain behaviour, ERIC Document Services No. ED 227 565, pp.43.

Keirsey, D. & Bates, M. (1978) Please understand me. 3rd Ed. Prometheus Nemesis Books, CA.

Kibby, M.R. & Mayes, J.T. (1989) Towards intelligent hypertext. In: McAleese, R. (Ed.) Hypertext: Theory into Practice. Intellect, Oxford.

Kilmann, R.H. & Taylor, V. (1974) A contingency approach to laboratory learning: Psychological types versus experiential norms. In: Human Relations, 27, pp.891-909.

Kirton, M.J. (1987) Kirton Adaption-Innovation Inventory (KAI) - Manual, (2nd Ed.) Occupational Research Centre, Hatfield, UK.

Knapp, P. & Seagrim, G. (1981) Visual memory in Australian Aboriginal children and children of European descent. In: International J. of Psychology, September, Vol. 16, No. 3, pp.213-231.

Kolb, D. (1978) The Learning Style Inventory: Technical Manual. McBer and Co., Boston, Mass.

Kolb, D. (1981) Experiential learning theory and the learning style inventory: a reply to Freedman and Stumpf. In: Academy of Management Review, Vol. 6, No. 3, pp.289-296.

Kolb, D. (1984) Experiential learning: Experience as the source of learning and development. Prentice-Hall Inc., Englewood Cliffs, New Jersey.

Kolb, D. & Goldman, M. (1973) Toward a typology of learning styles and learning environments: An investigation of the impact of learning styles and discipline demands on the academic performance, social adaptation and career choices of MIT Seniors. WP-688-73, Alfred P. Sloan School of Management, MIT.

Lacy, O.W. (1984) [Myers-Briggs Type Indicator and Strong-Campbell Interest Inventory]. Unpublished raw data. In: Myers, I.B. & McCaulley, M.H. (1985) Manual: A guide to the Development and Use of the Myers-Briggs Type Indicator. Consulting Psychologists Press, Palo Alto, California.

Laurel, B. (1991) Computers as theater. Addison-Wesley, UK.

Laurel, B., Oren, T. & Don, A. (1992) Issues in multimedia interface design: media integration and interface agents. In: Blattner, M.M. & Dannenberg, R.B. (Eds.) (1992) Multimedia interface design. ACM Press, New York.

Laurillard, D. (1979) The process of student learning. In: Higher Education, No.8, pp.395-409.

Laurillard, D. (1993) Rethinking university teaching: a framework for the effective use of educational technology. Routledge, UK.

Lawrence, G. (1993) People Types and Tiger Stripes: A practical guide to learning styles. Center for Applications of Psychological Type, Gainesville, FL.

Lawrence, G. (1984) A synthesis of learning style research involving the MBTI. In: Journal of psychological type, Vol. 8, pp.2-15.

Lawson, B. (1990) How Designers Think. 2nd Edition, Butterworth Architecture.

Lazzaro, N. (1991) Aesthetics and the interface. In: Multimedia Review, Vol. 2, No. 2, pp.9-12.

Lovell, R.B. (1989) Adult Learning. Routledge.

LTU (1988) Authoring of Computer Based Training Materials. Learning Technologies Unit, Employment Department, Sheffield.

Lueder, R. & Noro, K. (Eds.) (1994) Hard facts about soft machines: the ergonomics of seating. Taylor & Francis, UK.

Macdaid, G.P., McCaulley, M.H. & Kainz, R.I. (1986) The Myers-Briggs Type Indicator: Atlas of Type Tables. Center for Applications of Psychological Type, P.O. Box 13807, Gainesville, Florida 32604, USA.

MacKinnon, D.W. (1962) The personality correlates of creativity: A study of American architects. In: Nielson, G. S. (Ed.) Proceedings of the fourteenth international congress on applied psychology, Vol. 2, pp.11-39. Munksgaard, Copenhagen. (Reprinted) Vernon, P. E. (Ed.) (1970) Creativity , pp.289-311, Penguin.

MacLeod, C., Hunt, E. & Matthews, N. (1978) Individual differences in the verification of sentence-picture relationships. In: Journal of Verbal Learning and Verbal Behaviour, pp. 493-508.

Marchionini, G. & Shneiderman, B. (1988) Finding facts vs. browsing knowledge in hypertext systems. In: Computer, Vol. 21, No. 1, pp.70-80.

Margerison, C. & Lewis, R. (1981) Mapping managerial styles. In: International journal of manpower, Vol. 2, No. 1, pp.1-24.

Martray, C.R. (1971) An empirical investigation into the learning styles and retention patterns of various personality types. Doctoral dissertation, University of Alabama. Dissertation Abstracts International, 1972, 32, 5043A.

McAleese, R. (1990) Locus of control: does hypertext make adaptive/ intelligent systems obsolete? In: Rizk, A., Strietz, N. & Andre, J. (eds) Hypertext: Concepts, Systems and Applications. Proceedings of the European Conference on Hypertext, INRIA, France, November 1990, pp.339-340. Cambridge University Press, Cambridge UK.

McAleese, R. (Ed.) (1989) Hypertext: Theory into Practice. Intellect, Oxford.

McCaulley, M.H. (1978) Application of the Myers-Briggs Type Indicator to medicine and other health professions (Monograph 1). Center for applications of psychological type, Gainesville, FL.

McCaulley, M.H. (1981) Jung's theory of psychological types and the Myers-Briggs Type Indicator. In: P. McReynolds (Ed.) Advances in personality assessment (volume 5). Jossey-Bass, New York.

McCaulley, M.H. (1990) The MBTI and individual pathways in engineering design. In: Engineering Education, Vol. 80, No. 5, pp.537-542. American Society for Engineering Education.

McCaulley, M.H. & Natter, F.L. (1974) Psychological (Myers-Briggs) type differences in education. In: Natter, F.L. & Rollin, S.A. (Eds.) The Governor's Task Force on Disruptive Youth: Phase II Report. Tallahassee, FL, 1974.

McCrae, R.R. & Costa, P.T. (1989) Reinterpreting the Myers-Briggs Type Indicator from the perspective of the five-factor model of personality. In: Journal of Personality Vol. 57, No. 1, pp.17-40.

McCrae, R.R. & Oliver, P.J. (1992) An introduction to the five-factor model and its applications. In: McCrae, R.R. (Ed.) Journal of Personality, Vol.60, No.2,pp.177-215, Duke University Press, NC.

McKnight, C., Dillon, A., & Richardson, J. (1991) Hypertext in context. Cambridge University Press.

Messick, S. (1976) Personality consistency in cognition and creativity. In: Messick, S. (Ed.) (1976) Individuality in learning, pp.4-22, Jossey-Bass, San Francisco.

Mozart, W.A. (1789) Letter. In: Holmes, E., The life of Mozart including his correspondence 1878. Reprinted in Vernon, P.E. (Ed.) (1970) Creativity, pp.55-56,Penguin.

Muller, M.J., Farrell, R.F., Cebulka, K.D. & Smith, J.G. (1992) Issues in the usability of time-varying multimedia. In: Blattner, M.M. & Dannenberg, R.B. (Eds.) (1992) Multimedia interface design. ACM Press, New York.

Myers, I.B. (1962) The Myers-Briggs Type Indicator: Manual. Consulting Psychologists Press, Palo Alto, CA.

Myers, I.B. (1993) Introduction to type. (5th Edition.) Oxford Psychologists Press, UK.

Myers, I.B. & McCaulley, M.H. (1985) Manual: A guide to the Development and Use of the Myers-Briggs Type Indicator. Consulting Psychologists Press, Palo Alto, California.

Myers, I.B. & Myers, P. (1980) Gifts Differing. Consulting Psychologists Press, Palo Alto, CA.

Neilsen, J. (1990) The art of navigating through hypertext. In: Commun. ACM, Vol. 33, pp.297-310.

Nelson, T.H. (1974) Dream Machines. Second edition (1987) published as Computer Lib/Dream Machines by Tempus Books (Microsoft Press) Redmond, WA.

Nelson, T.H. (1981) Literary Machines. 2nd ed. 1987 (Self-published) Mindful Press, 2320 Marinship Way, Sausalito, CA 94965. (Hypertext edition of Literary Machines, 1987, 87/1 by OWL International).

Nelson, T.H. (1988) Managing immense storage. In: Byte, January, 225-238.

Nievergelt, J. & Weydert, J. (1987) Sites, modes, and trails: Telling the user of an interactive system where he is, what he can do, and how to get to places. In: (reprinted) Baecker, R.M. & Buxton, W.A.S. (Eds.) (1987) Readings in human-computer interaction: A multi-disciplinary approach. Morgan-Kaufmann Publishers, Palo Alto, CA., pp.438-441.

Nisbet, J.A., Ruble, V.E. & Schurr, K.T. (1981) Myers-Briggs type indicator: A key to diagnosing learning styles and developing desirable learning behaviors in high risk college students. In: Paper presented at 5th annual national conference on remedial developmental studies in post-secondary institutions, Dayton, OH.

Nisbet, J.A., Ruble, V.E. & Schurr, K.T. (1982) Predictors of academic success with high risk college students. In: Journal of College Student Personnel, pp.227-235.

Nolthuis, J. (1992) Multimedia and the art of linking reality. In: Blattner, M.M. & Dannenberg, R.B. (Eds.) (1992) Multimedia interface design. ACM Press, New York.

O'Shea, T. & Self, J. (1983) Learning and teaching with Computers. Harvester Press, Brighton.

Otis, G.D. (1972) Types of medical students. (Contract 71-4066) USPHS, National Institutes of Health.

Parker, R. (1988) The Aldus guide to basic design, 2nd Edition. Aldus Corporation, Seattle.

Parlett, M. (1969) The syllabus-bound student. In: Hudson, L. (Ed.) The ecology of human intelligence, Penguin Books, Harmonsworth UK.

Parlett, M. et al. (1988) Learning from learners: A study of the student's experience of academic life. SCED, Paper 54.

Pask, G. (1969) Strategy, competence and conversation as determinants of learning. In: Programmed Learning, October, pp.250-267.

Pask, G. (1976) Styles and strategies of learning. In: British Journal of Educational Psychology, Vol.46, pp.128-148.

Pask, G. & Scott, B.C.E. (1972) Learning strategies and individual competence. In: International Journal of Man-Machine Studies, Vol. 4, pp.217-253.

Perelman, L. (1992) School's Out: Hyperlearning, the new technology and the end of education. William Morrow, New York.

Peters, C.E. (1981) An investigation of the relationship between Jungian psychological type and preferred styles of enquiry. Doctoral dissertation, Ohio State University, Dissertation Abstracts International, 44 (06), 1974B.

Peterson, J. & Lansky, L. (1974) Left-handedness among architects: Some facts and speculation. In: Perceptual and motor skills, Vol. 38, pp.547-550.

Pittenger, D. (1993) The Utility of the Myers-Briggs Type Indicator. In: Review of Education Research, Winter.

Powell, J.A. & Newland, P. (1994) Informing multimedia: a sensitive interface to data for construction design professionals. In: Design Studies, Vol.15, No.3, pp.285-316.

Pratt, L.K., Uhl, N.P. & Little, E.R. (1980) Evaluation of games as a function of personality type. In: Simulation & Games, 11, pp.336-346.

Ramsden, P. (1992) Learning to teach in higher education. Routledge, London.

Richards, S., Barker, P., Giller, S., Lamont, C. & Manji, K. (1991) Page structures for electronic books. In: ETTI, Vol. 28, No. 4, pp.291-301.

Riecken, R.B. (1992) Human-machine interception and perception. In: Blattner, M.M. & Dannenberg, R.B. (Eds.) (1992) Multimedia interface design. ACM Press, New York.

Rivlin, C., Lewis, R. & Cooper, D.C. (Eds.) (1990) Guidelines for screen design. Blackwells Scientific Publications, Oxford.

Roberts, D.Y. (1982) Personality and media preferences among community college students. In: Research in psychological type, Vol. 5, pp.84-86.

Rogers, C.R. (1954) Toward a theory of creativity. In: ECT: A Review of General Semantics, Vol.11, pp.249-60, 1954. Reprinted in: Anderson, H.H. (Ed.) (1959) Creativity and its cultivation, pp.69-8, Harper Bros., New York.

Rokeach, M. (1960) The open and closed mind. Basic Books, New York.

Ross, J. (1961) Progress report on the college student characteristics study: June, 1961. Research Memorandum 61-11. Princeton, NJ: Educational Testing Service.

Saunders, D.R. (1955) Some preliminary interpretive material for the PRI. Research Memorandum RR-15. Educational Testing Service, Princeton, NJ.

Schmeck, R. (1985) Learning styles of college students. In: Dillon, R. & Schmeck, R. (Eds.) Individual differences in cognition: Vol. 1. Academic Press, New York.

Schroeder, E. (1991) Interactive Multimedia Computer Systems. ED340388 Nov 91, ERIC Clearinghouse on Information Resources, Syracuse, N.Y.

Schwier, R. A. & Misanchuk, E. R. (1993) Interactive Multimedia Instruction. Educational Technology Publications Inc., Englewood Cliffs, N.J.

Sculley, J. & Byrne, A. (1987) Odyssey: Pepsi to Apple. Collins, London.

Shneiderman, B. (1987) User interface design for the Hyperties electronic encyclopedia. In: Proceedings of the ACM Hypertext'87 conference, pp.189-194, Chapel Hill, NC, November.

Shouksmith, G. (1970) Intelligence, creativity and cognitive style. Batsford, London.

Smith, A. & Irey, R. (1974) Personality variables and the improvement of college teaching. Paper presented at the meeting of the American Educational Research Association, Chicago. ERIC document reproduction service No. ED 096 313.

Smith, A., Irey, R. & McCaulley, M.H. (1973) Self-paced instruction and college students' personality. In: Engineering education, Vol. 63, No. 6, pp.435-440.

Sperry, R., Gazzaniga, M. & Bogen, J. (1969) Interhemispheric relationships: the neocortical commissures; syndromes of hemisphere disconnection. In: Vinken, P. & Bruyn, G. (Eds.) Handbook of clinical neurology. Vol. 4., North-Holland, Amsterdam.

Stout, D. & Ruble, T. (1994) A reassessment of the role of the learning style inventory (LSI-1985) in accounting education research. In: The Journal of Accounting Education, Vol. 12, No. 2, pp.89-104.

Stricker, L.J. & Ross, J. (1962) A description and evaluation of the Myers-Briggs Type Indicator. Research Bulletin RB-62-6, Educational Testing Service, Princeton, NJ.

Stumpf, S. & Freedman, R. (1981) The learning style inventory: still less than meets the eye. In: Academy of Management Review, Vol. 6, No. 2, pp.297-299.

Swisher, K. & Deyhle, D. (1987) Styles of Learning and Learning of Styles: Educational Conflicts for American Indian/Alaskan Native Youth. In: Journal of Multilingual and Multicultural Development, Vol.8, No.4, pp.345-360.

Swisher, K. & Deyhle, D. (1989) The Styles of Learning Are Different, but the Teaching Is Just the Same: Suggestions for Teachers of American Indian Youth. In: Journal of American Indian Education; (special issue) pp.1-14, August.

Taylor, C.W. & Barron, F. (Eds.) (1963) Scientific creativity: its recognition and development. Wiley, New York.

Terman, L.M. (1947) Psychological approaches to the biography of genius. In: (Reprinted) Vernon, P.E. (Ed.) (1970) Creativity, pp.25-42, Penguin.

Thimbleby, H. (1990) User interface design. ACM - Addison-Wesley, UK.

Toffler, A. (1980) The third wave. Pan, London.

Torrance, E.P. (1962) Causes for concern. In: (Reprinted) Vernon, P.E. (Ed.) (1970) Creativity, pp.355-370, Penguin.

Wells, H.G. (1938) World Encyclopaedia. In: World Brain. Doubleday Doran, New York. Originally presented at the Royal Institution of Great Britain weekly evening meeting Friday November 20, 1936.

Williams, L.V. (1986) Teaching for the two-sided mind: a guide to right brain / left brain education. Simon & Schuster, New York.

Winograd, T. & Flores, C.F. (1986) Understanding computers and cognition: a new foundation for design. Addison-Wesley, Reading, Mass.

Witkin, H. (1969) Some implications of research on cognitive style for problems of education. In: Gottsegen, M. (Ed.) Professional school psychology, Vol. 3, pp.198-227. Grume & Stratton, New York.

Wittrock, M.C. (Ed.) (1977) The Human Brain. Prentice-Hall, Englewood Cliffs, N.J.

Woodhead, N. (1990) Hypertext and Hypermedia: Theory and Applications. Sigma Press, Wilmslow, UK.

Yankelovitch, N., Hann, B.J., Meyrowitz, N.K. & Drucker, S.M. (1988) Intermedia: The concept and construction of a seamless information environment. In: Computer, Vol. 21, No. 1, pp.81.

Yeomans, M. (1984) Spatial ability and its relation to design competence. MPhil. Thesis, CNAA, Liverpool Polytechnic.

Yokomoto, C.F. & Ware, J.R. (1982) Improving problem solving performance using the MBTI. In: Proceedings of the 1982 American Society of Engineering Education annual conference (ASEC), pp.163-167.

Zenhausern, R. (1990) Neuropsychological Bases of Educational Disabilities: Implications for Diagnosis and Remediation. Expert paper submitted to the United Nations Disability Unit, Vienna. February 1990. Archived at sjuvm.stjohns.edu/public.100/unpaper.disabled

Appendix A

Appendix A

Survey of UK design undergraduates

Following a pilot study carried out in a local FE college[1] a survey was undertaken of undergraduate students on typical design courses in UK universities.

Two universities were selected which offered undergraduate courses in both two-dimensional and three-dimensional art-based design studies. The survey was carried out at the Department of Three-Dimensional Design, Leeds Metropolitan University, for product design and furniture design; and at the Institute of Design, University of Teesside, for industrial design, graphic design, interior design, and design marketing. Samples were restricted to subject-specialist cohorts in their first year of study. The rationale for choosing first year students is because they are relatively unchanged by higher education, and any CAI programme would have to operate with students who are new to their studies. A total of 71 students was assessed. The subject specialisms covered were

- industrial design (product design/3D studies)
- interior design
- graphic design
- furniture design (3D studies)
- design/marketing (industrial design with marketing studies)

1 The pilot study was conducted at Cleveland College of Art & Design, Middlesbrough. The results of the pilot study are not recorded here.

Following a brief introduction, a questionnaire[2] was completed by each student. All students were volunteers. The primary data collected included

- the psychological type indicated
- name, and subject specialism of student
- date of the survey
- type scores

This was a relatively small scale survey intended only to establish whether the general direction of psychological types of cognate professionals would be shared by designers. The results clearly show these design students to have much in common with cognate professionals, but quite different preferences to a general population. A large percentage of designers cluster unexpectedly in one type.

Data are depicted overleaf, broken down into the same categories as shown in the *Atlas of Type Tables* (Macdaid, McCaulley & Kainz, 1986). The matrix shown also follows the original MBTI layout in order to facilitate direct comparison with other occupational data (cf. 3.5.3 for designers within the CAIUS matrix).

2 The abbreviated version of the MBTI (form AV, 50 items) was administered (cf. Myers & McCaulley, 1985, pp. 6 & 144 for a discussion of the instrument's validity and accuracy). The manual states that this form

> "can be used as a measure to classify individuals according to type. It should not be used to measure type scores" (pp. 145).

Type scores were recorded, but are not reported in this thesis. Form AV is of similar length to the *temperament sorter* (Keirsey & Bates, 1985, pp. 5-12) which has 70 items. Either instrument might be suitable for implementing on a computer as the style assessment part of a CAI application for naive users.

n=	71	
dimn.	n	%
E	51	71.8
I	20	28.2
S	15	21.1
N	56	78.9
T	42	59.2
F	29	40.8
J	22	31.0
P	49	69.0
IJ	8	11.3
IP	12	16.9
EP	37	52.1
EJ	14	19.7
ST	8	11.3
SF	7	9.9
NF	22	31.0
NT	34	47.9
SJ	5	7.0
SP	10	14.1
NP	39	54.9
NJ	17	23.9
TJ	15	21.1
TP	27	38.0
FP	22	31.0
FJ	7	9.9
IN	15	21.1
EN	41	57.7
IS	5	7.0
ES	10	14.1
ET	31	43.7
EF	20	28.2
IF	9	12.7
IT	11	15.5
S dom	9	12.7
N dom	36	50.7
T dom	16	22.5
F dom	10	14.1

	ISTJ	**ISFJ**	**INFJ**	**INTJ**
n=	1	1	2	4
%	1.4	1.4	2.8	5.6
	ISTP	**ISFP**	**INFP**	**INTP**
n=	2	1	5	4
%	2.8	1.4	7.0	5.6
	ESTP	**ESFP**	**ENFP**	**ENTP**
n=	2	5	11	19
%	2.8	7.0	15.5	26.8
	ESTJ	**ESFJ**	**ENFJ**	**ENTJ**
n=	3	0	4	7
%	4.2	0.0	5.6	9.9

Survey of UK design students

Appendix B

Appendix B

Personality characteristics: source data for learning styles

The following is a selection of broad characteristics resulting from the dichotomised scales of the MBTI, with pointers to learning style preferences. Specifications for CAI have been derived from these general characteristics (cf. 5.3).

Following an extensive review of the MBTI literature, a small number of key texts were selected. They are highlighted here in order to assist readers wishing to undertake a more detailed study of the subject. Although some additional documents are referred to in Chapter 5, the primary sources of information on learning styles related to the MBTI scales which have been consulted are as follows. Data have been collected and classified under a number of headings ranging from general background characteristics through to more detailed recommendations.

The manual for the MBTI, *Manual: A guide to the Development and Use of the Myers-Briggs Type Indicator* (Myers & McCaulley, 1985) is a prime source of detailed information. The manual comprises not only an introduction to the use of the MBTI, but also shows correlations with other scales, provides a review of research connected with learning styles, and publishes many other data related to the MBTI scales. For background information there are several texts which introduce the MBTI and provide the underpinning characteristics which are helpful in understanding differences in learning style: these include the books *Gifts Differing* (Myers & Myers, 1980); and *Introduction to Type* (Myers, 1993). Thimbleby (1990) is one of the few texts which, while dealing with human-computer interaction, sets out the case for the use of personality attributes playing a potentially important part in human-computer interaction, and specifically cites Jungian theory. The book is also helpful due to its many analyses of relations

between humans and computers. For raw data on occupational groups, the *Myers-Briggs Type Indicator: Atlas of Type Tables* (Macdaid, McCaulley & Kainz, 1986) is a corpus which warrants much careful study. An article published in *Engineering Education* (McCaulley, 1990) is useful in understanding learning styles particularly in engineering students, and provides ideas for teaching to style. It also reports a large scale longitudinal study of engineering student cohorts.

There are many works which report observations of the behaviours of groups of people in the context of Jungian psychology and styles of learning. Two are preeminent. The book *Please Understand Me* (Keirsey & Bates, 1978) is notable for its highly detailed descriptions of the types and their preferences for, among other things, learning. It is also useful for its description of the *temperament sorter*, an MBTI-like questionnaire which could be implemented on a computer to assess the learning styles of students prior to them undertaking CAI. Another book in this genre is *People Types and Tiger Stripes* Lawrence (1993) who makes many behavioural observations and has published arguably the best links with learning styles: additionally, there is practical advice about teaching to style. Lawrence (1984) offers a comprehensive synthesis of learning style research involving the MBTI. It is a good source for commentary on previous studies. In the area of interesting correlational data, Margerison & Lewis (1981) discuss the mapping of managerial styles, and McCrae & Costa (1989) show links between their five factor model of personality and the MBTI. Although not directly related to Jungian theory some researchers have advocated the use of a single scale such as the serialist-holist dimension. This is of interest due to its similarity with the SENSING • INTUITION scale of the MBTI. Clarke (1993) deals with learning in holistic or serialistic ways, and methods for computer implementation.

Three doctoral theses are particularly useful. Peters (1981) was a careful and highly detailed investigation of the relationship between Jungian psychological types and preferred styles of enquiry. Diehl (1992) was concerned with the relationship between creativity, imagery, and Jungian types, and used as her

subjects interior design majors. Data arising from this study have been reported above (cf. 3.4.6). Eggins (1979) deals more directly with the interaction between Jungian type in learners and the structure of learning materials. Although this study was of schoolchildren, it provides some insights into preferences for various kinds of instructional models.

A selection of characteristics follows, based on teaching and learning styles in relation to computer delivery. These data are presented as a matrix which shows the more general characteristics which are suitable for learning. Each matrix represents one end of a dichotomised scale. The meanings ascribed to each of the boxes is explained as follows.

Characteristics		
General description		This is a general description of the main traits exhibited by this dimension.
General characteristics		These are general descriptions of the makeup of this dimension, broken down into specific pointers.
Learning preferences	**Like**	These are general preferences related to a learning situation.
	Dislike	These are general areas of dislike in a learning situation.

General characteristics.

Characteristics of EXTRAVERSION

EXTRAVERSION - characteristics		
General description		EXTRAVERSION relates to the outer world of people and things: extraverts are comfortable with other people and prefer to work in groups.
General characteristics		Like to have people round them. Prefer working with a group to working alone. Like talking and discussion, and face to face activities. In group discussions will handle impromptu questions well. likely to begin answering questions immediately, thinking of what they say as they speak. Some impulsivity. Tends to act first, reflect afterwards. Often dominant, enjoy being in charge and making things happen. Enjoy physical interaction. Have a need for stimulation through variety and action. Need to take frequent and active breaks from an otherwise solitary task. May be easily bored. Not bothered by interruptions. Not naturally interested in learning for its own sake. Little patience with confusion and inefficiency.
Learning preferences	**Like**	Require immediate and tangible results. Enjoy studying with a friend. Prefer learning through interactions, verbal and non-verbal. Talking may help to form and clarify thoughts. Like opportunities to think out loud, for example one to one with a teacher. May understand texts better if they process them orally. Enjoy plunging into new material. Attend to learning through a trial and error process. Like learning activities that have an effect outside the learner, such as visible results from a project. Prefer frequent and active breaks.
	Dislike	Dislike complicated procedures. Need to have a strong, interesting reason for studying, beyond learning for its own sake. May tend to leap into academic tasks with little planning or consideration. may have difficulty concentrating on study (especially reading) for long periods. Often impatient with long, slow projects.

Characteristics of INTROVERSION

INTROVERSION - characteristics		
General description		INTROVERSION relates to one's own inner world of ideas and concepts: introverts are comfortable when working quietly alone.
General characteristics		Have a natural interest in enduring concepts and ideas. Need to keep their privacy. Some dislike of group activities. Quiet reflection before acting. Prefer to be given notice of questions in group discussion. Need to have time to hone their work before presenting it. Are not overly talkative. May have trouble remembering names and faces. Dislike transitory events.
Learning preferences	**Like**	Main way of studying is through reading. Significant amount of book reading. Demonstrates independence, therefore solitary study is acceptable. Learning in private, individual ways. Need quiet for concentrated study, think best when alone. Are able to concentrate for long stretches of time on a single topic. Verbal reasoning. Accept listening to others talk about the topic being studied. Prefer to consider reply before answering questions. Good at self evaluation. Like to process their experiences at their own pace, and time for internal processing. Careful with details. Process in depth. Prefer to concentrate on a few tasks at a time.
	Dislike	May lose concentration by becoming lost in daydream. Do not see experiential training as helpful. Are irritated by interruptions. Dislike sweeping statements.

Characteristics of SENSING

SENSING - characteristics		
General description		SENSING is perceiving reality directly through the senses. It is characterised by a reliance upon facts and experience, together with realistic, practical interests.
General characteristics		Realists, with a grasp of past and present. Memory for facts, and attentive to details and specifics. Careful and thorough observation, patient with routine details. Try not to make errors of fact; aim towards soundness of understanding, with objectivity and impartiality. Problems are solved by standard methods, logically and sequentially. Tend to be precise and detailed in personal communications. Not attentive to what is not immediate, attend to what is actual. Prefer skills and facts which can be used in the present life. Like information based upon what is measured, classified etc. Respect for authority as a source of expertise. Like an established order for doing things, and schedules. Like computer aided instruction!
Learning preferences	**Like**	Enjoy practising skills already learned. May benefit from having lessons repeated. Emphasis on facts, concrete examples, and practical solutions. Likes to put into immediate use what has been learned. Prefer work with real objects, with materials that can be handled. First hand experience giving practice in skills and concepts to be learned. Strive for mastery of specific examples, then look for connections and patterns. Need for clear and concise directions, and show exactly what is expected of the learner. Expect the teacher to make things explicit. Require facts before concepts. Start with familiar verifiable concrete facts, then introduce concepts and abstract principles. Process information sequentially, step by step with clear examples. Learn best with a linear instructional model. Films and other audio-visual presentations; television; and hands-on workshops.
	Dislike	Dislike learning for its own sake. Learning should have a tangible, practical outcome. Dislike theoretical tasks. May only focus on facts and details, and neglect concepts, connections between facts, and their interpretation. May have difficulty generalising beyond immediate facts. May not discover specific facts or concepts by themselves. Dislike new problems unless there are standard ways to solve them. Impatient when details get complicated or ambiguous. Disregard possibilities not based on solid facts. May only focus on facts, and neglect concepts, connections between facts, and their interpretation. Dislike moving through the lesson too quickly.

Characteristics of INTUITION

INTUITION - characteristics		
General description		INTUITION is internal SENSING using imagination, seeking possibilities, preferring patterns, relationships and problems beyond the reach of the senses. It is characterised by a reliance upon insight, and looks towards the future, searching for possibilities.
General characteristics		Future oriented, with explorations beyond realities of the present and past. Have intellectual interests which rely on insight, inspiration or hunches. Take information by means of imagination, by seeing the whole. Impressions are gained in fluid global, diffuse ways. Are imaginative. May enjoy fantasy and fiction. Metaphor and vivid imagery appeals. May find dreams fascinating. Sometimes find complex ideas coming as a whole, unable to explain how they knew. Show independence of thinking. Considerable enjoyment of books. Like opportunities to solve problems in new ways, and to be inventive, original, and ingenious. Like to explore new skills rather than hone present ones. Enjoy self-instruction and finding own way in new material. Works in bursts of energy, with slack periods between. Patient with complicated situations. May more readily see other points of view. To more sensible persons, may seem flighty, impractical, or unrealistic. Does not rely on memory of facts. Not pay so much attention to details and practical matters, but prone to making greater factual errors. Dislike doing the same thing repeatedly.
Learning preferences	**Like**	Prefer concepts first, will attend to details only after the big picture is clear. Light instructional structure which allows the seeing of relationships and common characteristics. Like tasks that call for grasping general concepts and in seeing associations, meanings, and possibilities. Enjoy original organisational patterns and general directions. Prefer independent study and self-paced learning on own initiative, real choices in the way they learn. Enjoy experiences rich with complexities. In a learning situation, will jump into new material to pursue an intriguing concept. May hop from concept to concept. Manipulation of symbols. Books, metaphor, imagery, stimulating lectures. Examinations that include open-ended answers.
	Dislike	May be annoyed if nothing is left to the imagination. May be reluctant to focus on details and learn facts. Impatient with routine or mechanical approaches to learning. May find continued practice of learned skills boring. Dislike taking time for precision. Reluctance to accept traditional instruction and testing. May misinterpret multiple-choice questions, making them more complex than intended. Get frustrated with instruction that is too slow.

Characteristics of THINKING

THINKING - characteristics		
General description		A THINKING preference is characterised by analytical, logical, evaluative and objective modes of thought: this is an impersonal basis for choice. It values being objective, and is 'thing-centred'.
General characteristics		Like analysis and things put into logical, cause-and-effect order, especially with ideas, numbers, or physical objects. Impersonal judgments free from emotions. Mental life is ordered by logical principles, step-by-step logical process of reasoning. Aims toward objective truths, values being objective and logical. Analyses experiences to find underlying logical principles and bring order out of confusion. Naturally critical, aims towards clarity and precision. Is thing-centred. Strong need for fairness. Awareness of standards. Little redundancy in communications, feeling that reason alone is convincing. Adapts past experiences to problem solving. Requires objective criteria for decisions. Requires evidence and concrete facts. May like working with figures, or take a statistical approach. Talk of markets, not people.
Learning preferences	**Like**	Wants to know that learning will lead toward understanding of the systematic way that the world works. Able to study without interpersonal harmony, firm-minded. Require objective material for study, and need to get a sense of mastery, perhaps through feedback showing objective achievements in learning. Like teachers who are logically organised. Prefer structured courses with clear goals and performance criteria. Learn best when given clearly presented set of performance criteria. Like subjects and materials that flow logically and respond to logic. Prefer depth and accuracy of content. Have tolerance of 'dry' academic texts. Lectures and demonstrations.
	Dislike	Assumes logic speaks for itself. In teaching, this may lead to not stating the obvious and to not repeating points. Dislike of subjectivity. Uncomfortable with value judgments, particularly related to people and dealing with emotions.

Characteristics of FEELING

FEELING - characteristics		
General description		FEELING people are more subjective, utilise sympathy and empathy, and prefer to weigh personal values. FEELING reaches decisions based on personal or social values. Choices are made by personalising considerations. Being less impressed by logic, it values the skills of communication. It is subjective, and is 'people-centred'. FEELING is a powerful tool for appreciation and persuasion.
General characteristics		People centred. Decisions based on analysis concerning human motives and personal values. Decisions are related to own perspective on life. Orders events in a hierarchy of more valuable or less valuable etc. Discriminate easily between good/bad, beautiful/ugly, moral/immoral etc. Strong need to understand humankind. Aware of other people and their feelings, and tend to be sympathetic. Naturally appreciate people and their accomplishments. Actions consider effects on people. Attend to skills of communication. Need occasional praise, respond well to any acknowledgement of them as individuals. May exhibit strong beliefs, with religious, political or humanitarian views, and principles. Personalise issues and causes they care about. May polarise issues either for or against. Measure decisions against beliefs. Favour interpersonal harmony, and stay tuned to the quality of the subjective tone of relationships. Like work that provides service to people. Sometimes take liberties with logic. May have difficulty thinking in conditional modes. Nostalgic, may hold to traditional ways.
Learning preferences	**Like**	Choose topics to study about which they care deeply. Like teachers to have personal rapport with students. Prefer projects that have a goal of helping people. Learning by helping and responding to other peoples needs. Studying with a group or with a friend. Feedback with warm appreciation for the student and her effort, and corrective suggestions in context.
	Dislike	Dislike numerical data and business connotations. Sensitive to tone and style. Become bored with texts that do not engage with their personal values. Often complain about topics that are dry and boring.

Characteristics of JUDGMENT

JUDGMENT - characteristics		
General description		JUDGMENT emphasises thinking in an orderly manner, aims to control events, and is associated with closure and the settling of things. Used to deal with the outer world, it is characterised by planning and structure, and leads to an organised and decisive approach.
General characteristics		Like to have issues clarified and resolved. Aim towards getting closure and completion. Satisfied once they reach a decision on a thing, person, or situation. Are respectful of logic. Life is organised into an orderly plan. Prefer work that imposes need for system and order. often seen as more organised, motivated, and decisive. As students, likely to be seen as goal oriented, responsible, and dependable. Will work well to deadlines. Tend to meet deadlines by limiting commitments and focusing on one task at a time. Accountable for and by what standards they will be judged. Like predictability and consistency. Less mature JUDGMENT types may be seen as rigid and close minded, may therefore decide things too quickly.
Learning preferences	**Like**	Like a preplanned structure, and will work efficiently to schedules. Thrive under clear assignments, goals, deadlines and structure with prescribed tasks indicated at the beginning. Like formalised instruction with material presented in an orderly way. Want only the essentials needed to begin. Draw energy from the steady orderly process of working. Treat assignments seriously and persist in completing them, tend to get them in on time. Gauge their academic progress by their accomplishments. Take pleasure in accomplishing tasks, writing papers, reading books, or making presentations etc. Prefer milestones or completion points, with little ceremonies to honour successful completions. Tend to be 'overachievers' ie. do more work than necessary for the task. Like workbooks, lectures, and demonstrations.
	Dislike	Uncomfortable with ambiguity and vague ideas. Unhappy with open-endedness.

Characteristics of PERCEPTION

PERCEPTION - characteristics		
General description		PERCEPTION is used to deal with the outer world, and leads to an adaptable, interested and spontaneous approach. It is characterised by curiosity and exploration, coupled with openness to experiences.
General characteristics		Curious, open-minded, and flexible. Welcome new light on a situation, thing, or person. Flexible, adaptable, and spontaneous way of life, following their curiosity. Staying open to new experience. Like work that requires adapting to changing situations, or where understanding situations is more important than managing them. Good at managing emerging problems. Something new and different is a stimulation. Work feels like play. Want to get as much information as possible before deciding directions. Prefer to pursue problems in their own way, problem solving conducted in an informal manner. Less mature PERCEPTION types may be seen as undependable and changeable, and may have trouble making decisions.
Learning preferences	**Like**	Tend to view learning as a free wheeling, flexible, and thorough quest which may never end. Happy with open-endedness and tentativeness. Do not mind leaving things open for alterations. Tolerant of ambiguity. Likely to gather information indefinitely, and have trouble limiting themselves to meet deadlines. May want information beyond what is reasonable in the circumstances. Enjoy independent study programs, and like genuine choices in assignments. Prefer open-ended exploratory structure, not preplanned structure. Searching and finding. Exploration under user control. Discovery tasks. Tend to select broad topics and dive into research without limit. Studying to discover something new to them. Happy to work on several projects at once. Tend to thoroughly process information. Study when surges of impulsivity come to them.
	Dislike	May feel imprisoned and restricted by a highly structured delivery. Thoroughly processing texts may cause slow reading. Tendency to gather information indefinitely, therefore may become bogged down in research. May let work pile up, having to cram at the end.

Appendix C

Appendix C

Published papers

The following two papers were published during this study, and are referred to in the main text. These papers are:

Durling, D. (1994) Hyping style: approaches to design. In: Interact, Vol. 1, No. 4, pp.19-21, URL <http://valley.interact.nl/av/org/interact/supindex.html>

Durling, D. (1995) Virtual personalities. In: Proceedings of conference 4D Dynamics, September 1995, De Montfort University, UK.

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